EARTH SATELLITE CORPORATION
(EarthSat)

2150 SHATTUCK AVE., BERKELEY, CALIFORNIA 94704 / (415) 845-5140

INTERPRETATION AND EVALUATION OF THE GEOTHERMAL POTENTIAL FOR BIEBER, CALIFORNIA

for

EASON OIL COMPANY

January 27, 1972

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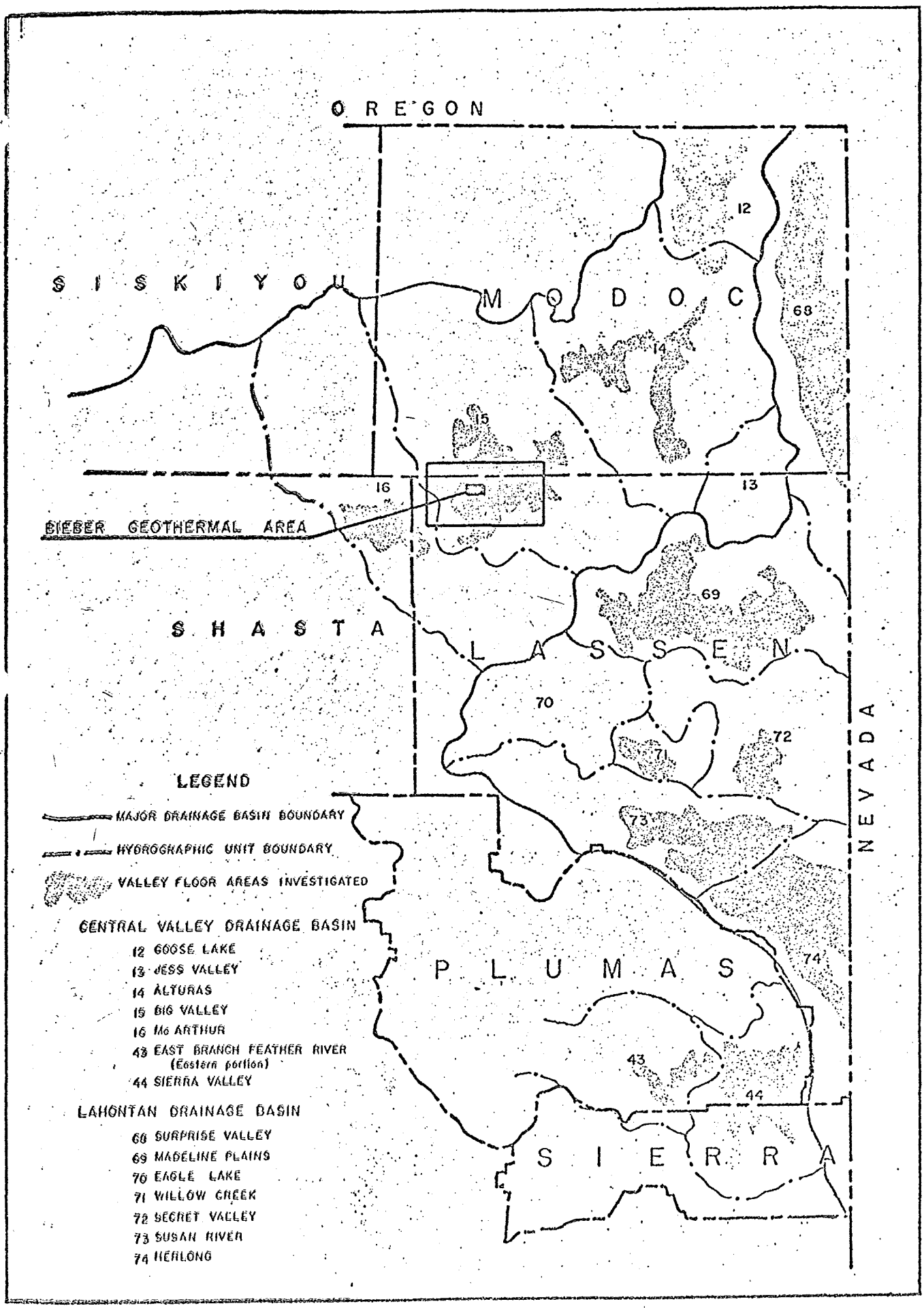
NOTE: The base maps in Figures 2 through 6 are for reference in facilitating only approximate geographic placement of the transparent overlays.


OREGON
SISKIYOU
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BIEBER GEOTHERMAL TARGET AREA

Introduction

From 1955 to 1972 over 50 wells have been drilled in approximately 17 California geothermal areas for the purpose of exploring and developing natural steam and hot water for electric power generation.

There are, in addition to these better publicized areas, other areas that show as much or more promise for geothermal potential. One of these, referred to as the "Bieber area", is located in Big Valley, northeastern California (refer to location map, Figure 1).

The majority of wells drilled to date have been on hot spring surface manifestations only, without the aid of geological and geophysical data to determine the location of the heat source at depth.

Approach

In the Geysers and Salton Sea geothermal areas, it became apparent as the fields were developed that the heat sources and reservoirs were not located directly under the hot springs, but were in some cases at a considerable distance from the springs. Case histories of these two areas indicate that the following information can help delineate the locations of these heat sources and reservoirs:

(1) High altitude and high speed infrared scanner data (8 - 14 microns)

(2) Gravity

(3) Magnetics

(4) Infrared photography

(5) Hot spring locations, ground water depths, water chemical analysis and flow directions

(6) Comparison of the above to existing geological maps.

In this report, we have compiled all the above data (except magnetics) at a scale of 1:62,500, as transparent overlays superimposed on the USGS topographic map (see Figure 7).

Analysis and Selection

Bassett and Kellog Hot Springs are indicated by the yellow squares on the base map. The water temperature and flow rates of these two springs are, respectively, 173°F., 175 GPM and 110-165°F., 126 GPM. Other areas of geothermal potential marked on the transparency are: (1) a hot spring in section 10, (2) warm water entering the Pit River in sections 36 and 35, and (3) hot water in section 1.

The water in the vicinity of the hot springs is not recommended for drinking or irrigation because of high concentrations of sodium sulfate, fluoride and boron. These elements are excellent indicators of geothermal energy at depth.*

Contours of water in wells from acquifers, shown on the transparency, are in 10-foot intervals in feet above sea level.* Note that the water table in the target area is close to the surface and that the flow direction is predominately away from the gravity high (Figure 2).

The Bouguer gravity contour transparency** delineates a seven milligal high northeast of the town of Bieber in the center of Big Valley (sections 11, 12, 13 and 18). Depth-to-basement calculations indicate that the basement is approximately 2,900 feet below the surface at this location. We believe that this anomaly is related to an increase in density of the bedrock due to local metamorphism caused by the geothermal sources. The warm water located

*State of California, Dept. of Water Resources Bull. No. 98, "Northeastern Counties Ground Water Investigation". Vol. II, February 1963.

**Gravity data obtained from Department of Water Resources, State of California.

south of the target area is most likely being heated by this source and is being carried by the acquifers down the valley.

A number of major fault zones are apparent in both the thermal and photo interpretations (Figures 6, 7). Bassett Hot Springs is located on the intersection of two faults. A large circular fault controls the drainage of the East Fork of Juniper Creek and a branch of the Pit River. These types of faults are often associated with Tertiary and Pleistocene volcanism in geothermal areas.

The yellow and red areas shown on the thermal interpretation transparency (Figure 3) are areas of "warm" and "hot" ground. We feel that the heat of the areas located in the southeast corner of the transparency is most likely the result of topography and lithology. The basalt flows in this area tend to retain more solar heat than do the surrounding rocks. However, to make sure of this, it is recommended that ground temperatures be measured by means of a thermistor in holes that are approximately three feet deep in order to eliminate the diurnal heating effect of the sun.

Optical and electronic enhancement of the infrared scanner data helps to extract more data than are shown on the black-and-white prints made directly from the imagery. EarthSat uses an International Imaging Systems (I^2S) 4000 Digicol Viewer with an analog signal processor accessory (see Figure 10) to aid in the final interpretation of the target areas. This equipment utilizes density slicing with color enhancement to bring out subtle features. To operate this instrument, the imagery is placed on a light table where a high resolution video camera scans the imagery and converts the data, which enables the signal processing circuitry to quantize the video signal output, assigning up to 32 levels of color to the ten grey levels of

the original film. The operator then adjusts the signal and selects color levels which maximize subtle variations in the density contrast of the original film that can be viewed on the color screen of an accompanying TV monitor. Figure 11 is a photograph of imagery of the southern and southeastern portion of the target area as viewed on the TV monitor of the Digicol output. Yellow denotes the hottest ground and thermal water locations, with red, green, blue and light blue representing decreasing temperatures. The large red and yellow areas are the Pleistocene basalts previously mentioned.

In addition to the false color image enhancement, we also used an edge enhancement technique. This technique is useful in detecting subtle thermal lineations. The process was performed by the I^2S Analog Signal Processor utilizing a high resolution (1029 lines/frame) TV Monitor. Briefly stated, two electronically generated channels of the same image are viewed with a very short time delay (offset) that enhances subtle gradient or edge effects that are normally overlooked when examined directly on the original imagery. The warmer areas are lighter in intensity with the colder ground being dark. The resultant image on the TV Monitor has a pseudo-three-dimensional effect with the warmest areas being shown as raised ground (max. Δ temp.) and the colder areas as lowered ground. The photograph of the TV Monitor (Figure 12) displays a number of detailed faults that are detectable on the edge enhancement. We recommend that these areas be examined on the ground before final selection of a drill site.

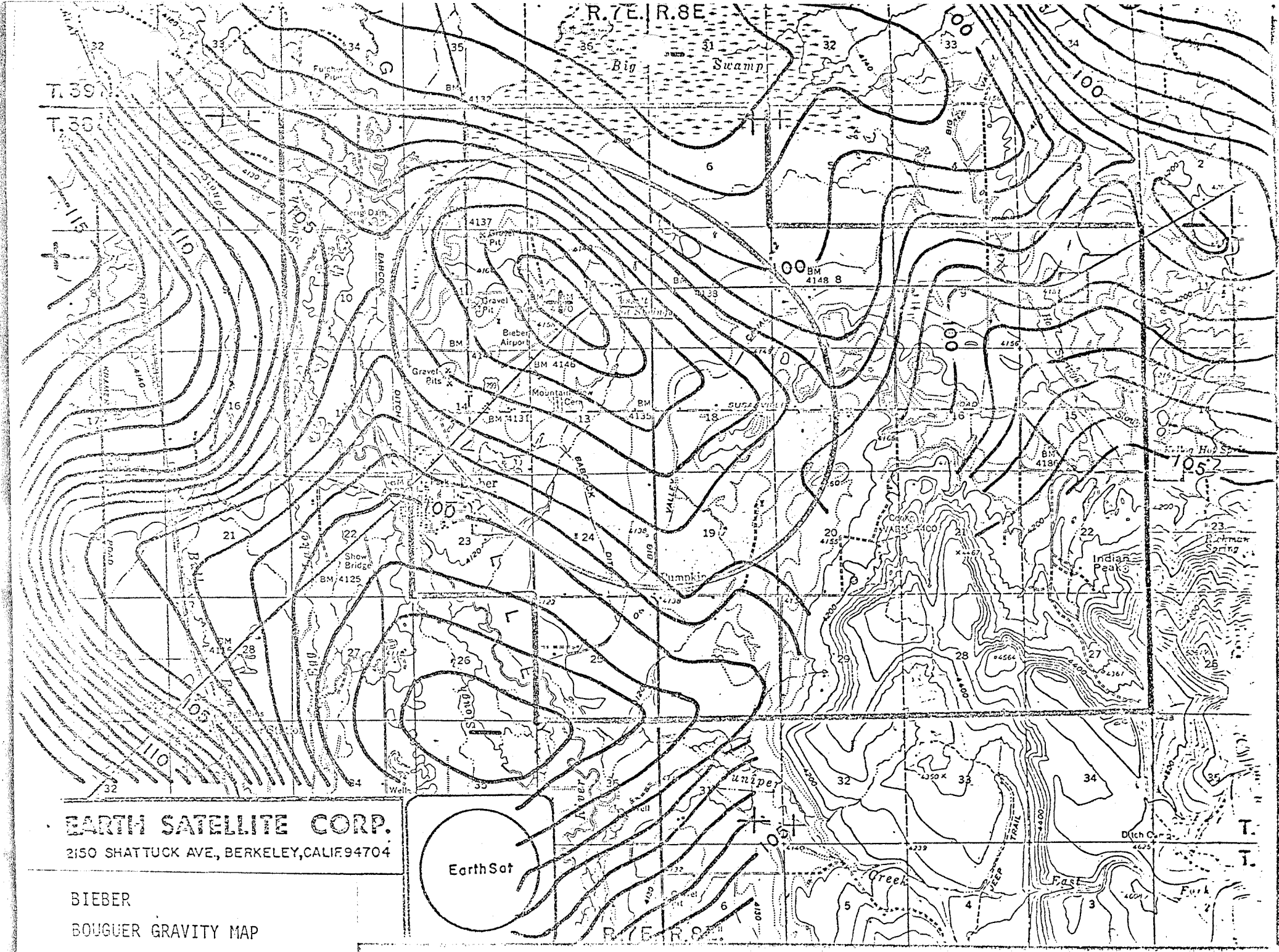
Recommendations and Selections

The circular target area represents the best location in the Bieber area for development of a geothermal field. The strongest data supporting this location are the positive gravity anomaly which indicate the presence of a geothermal source at depth. This source is expressed on the surface by

Bassett Hot Springs which has a relatively high temperature for a hot spring (173°F.). The stratigraphic column and cross section in this area indicates a relatively thick (2,900 ft.) sequence of sedimentary units with high porosity and permeability.

The photo and thermal lineations indicate that at least two or three major fault systems transect the target area. These faults may control the flow of thermal waters from the source to the surface.

Although this area is a good prospect, it has no past history of drilling, and therefore land should be easily obtained within the target area. Future field work, including ground geophysical surveys of deep resistivity, self potential and ground magnetics could help delineate thermal water zones and the location and depth of the local heat source.



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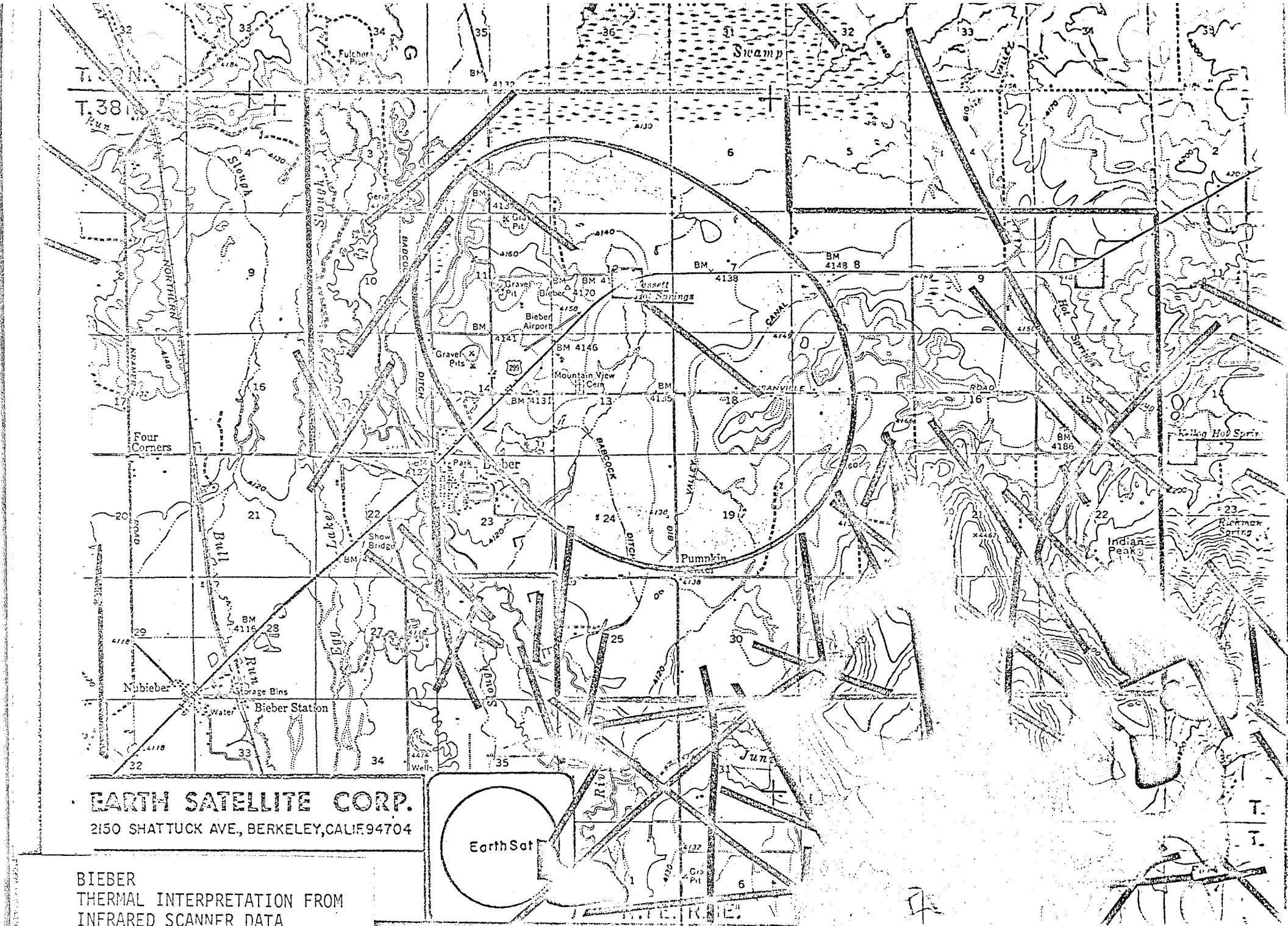
BIEBER

BOUGUER GRAVITY MAP



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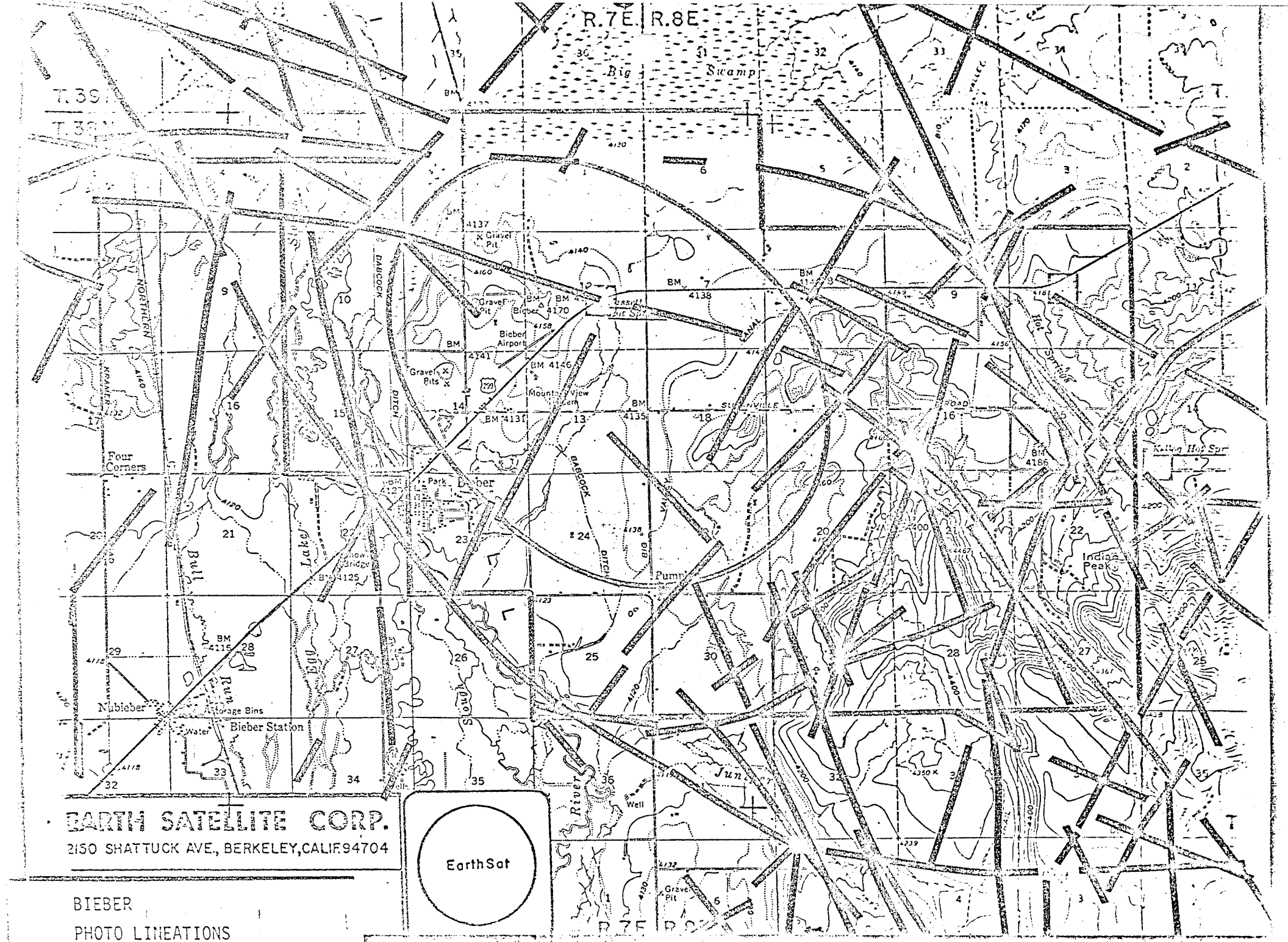
BIEBER
THERMAL INTERPRETATION FROM
INFRARED SCANNER DATA


R.7E. R.8E.
T.39
T.38
Big Swamp
Four Corners
Bieber
Bieber Airport
Mountain View Cem.
Gravel Pits
Lake Bull Run
Babcock Ditch
Big Valley Canal
Northern Canal
Hot Springs
Indian Peak
Nubieber
Storage Bins
Water
Bieber Station
Slough
Pumping Plant
Well
Gravel Pit
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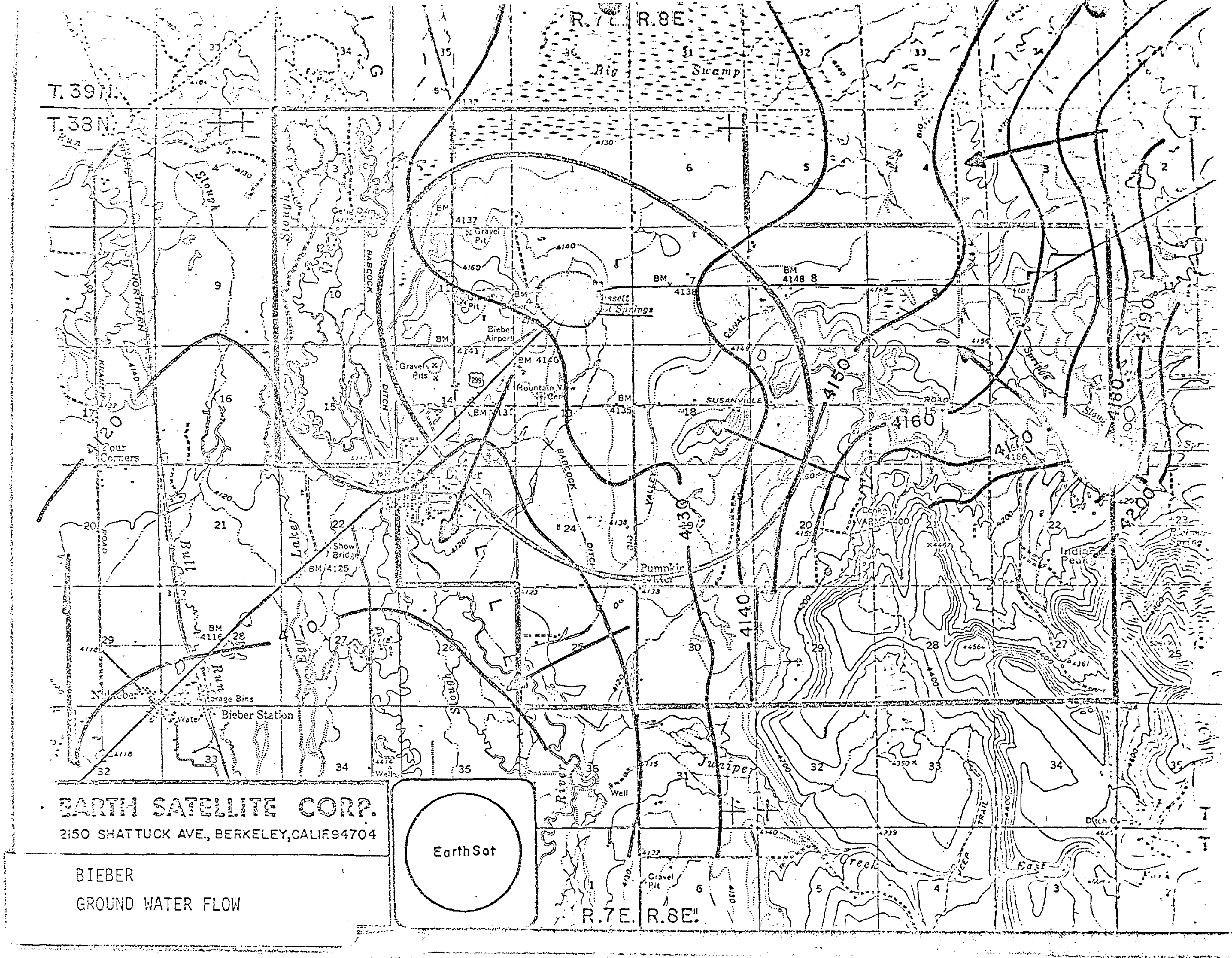
EarthSat
BIEBER
PHOTO LINEATIONS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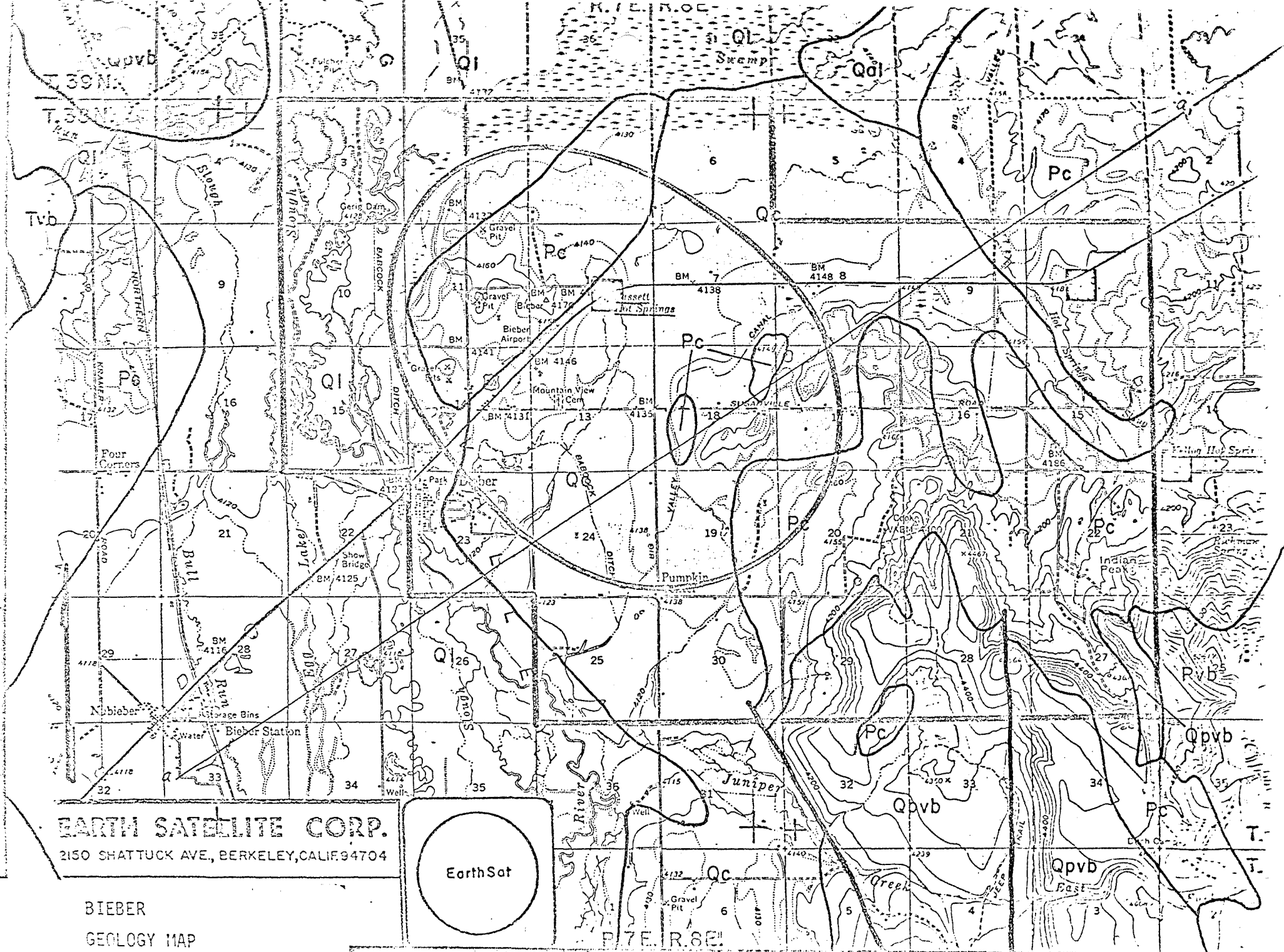
2150 SHATTUCK AVE., BERKELEY, CALIF. 94704
EarthSat
BIEBER
GROUND WATER FLOW
T.39N.
T.38N.
R.7E. R.8E.
Big Swamp
4190
4180
4160
4150
4140
4130
4120
Bieber Airport
Bieber Station
Four Corners
Pumpkin Center
Mountain View Cem
Indian Peak
Susanville Road
Babcock Ditch
Northern
Kramer Road
Bull Run
Juniper Creek
Slough
Gravel Pits
Storage Bins
Show Bridge
Canal
Valley
Well


T.39N.
T.38N.
R.7E.
R.8E.
Swamp
Qal
Ql
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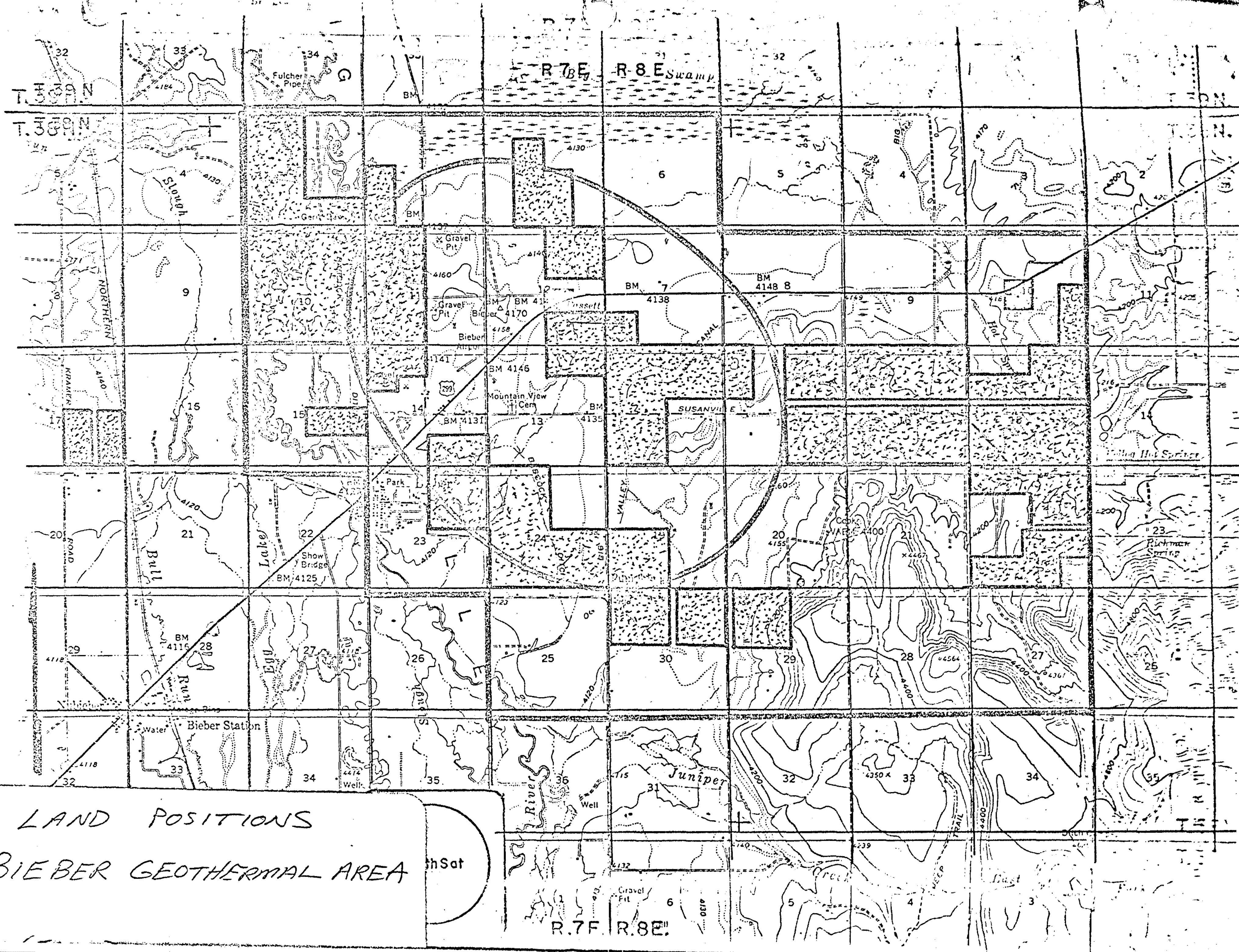
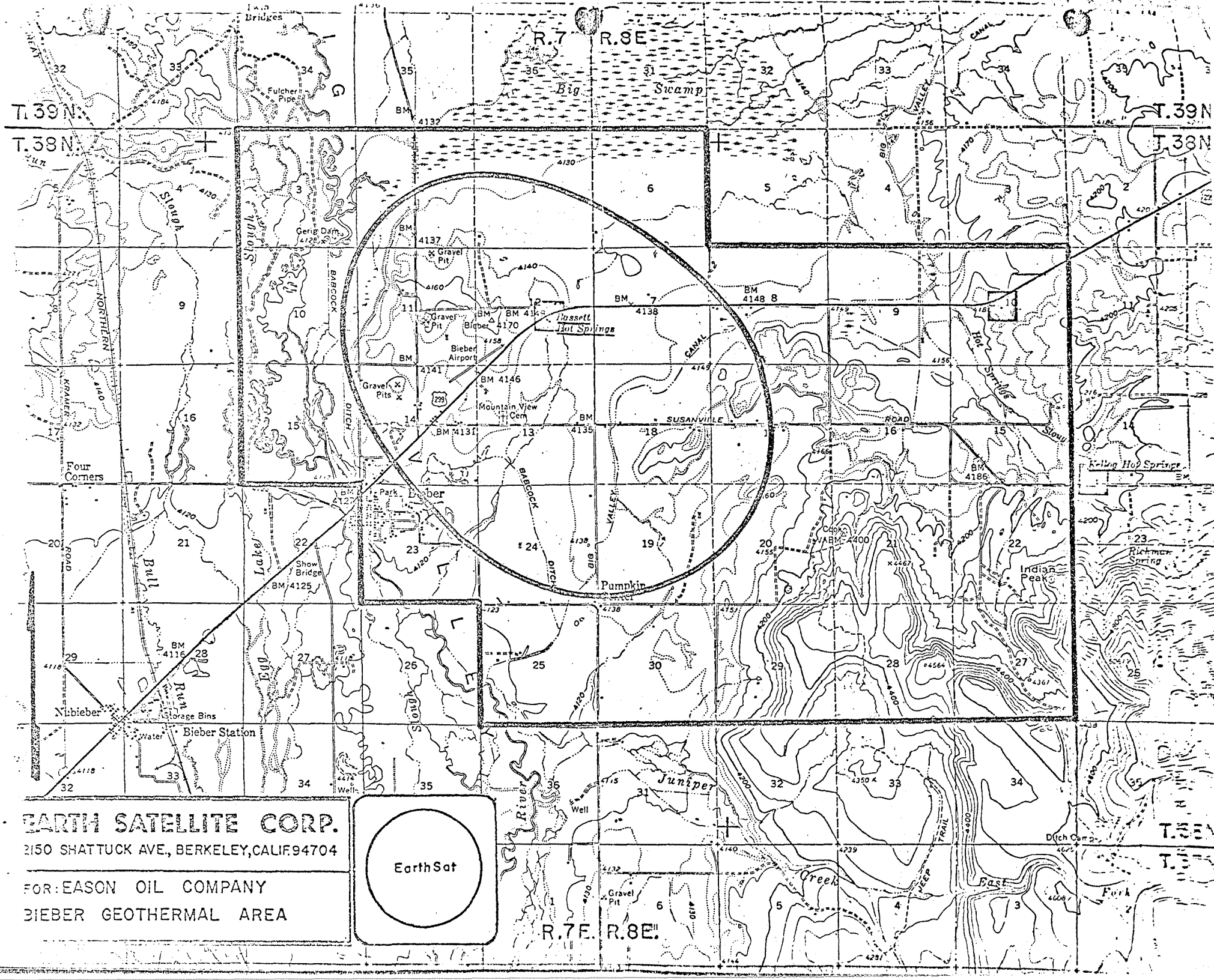
Qc
Tvb
Qpvb
Rvb
Slough
Gerig Dam
Gravel Pit
Bieber Airport
Hot Springs
Canal
Mountain View Cem
Siskiyou
Four Corners
Park
Bieber
Lake
Bull
Run
Egg
Shaw Bridge
Pumpkin
Indian Peak
Rushmore Spring
Boiling Hot Spring
Storage Bins
Water
Bieber Station
Juniper
Creek
Qpvb East
Well
Gravel Pit
EARTH SATELLITE CORP.
2150 SHATTUCK AVE., BERKELEY, CALIF. 94704
EarthSat
BIEBER
GEOLOGY MAP



LAND POSITIONS
BIEBER GEOTHERMAL AREA


R.7 R.8E
T.39N.
T.38N.
Big Swamp
Slough
Gerig Dam
Gravel Pit
Bieber
Bassett Hot Springs
Bieber Airport
Gravel Pits
Mountain View Cem
SUSANVILLE ROAD
Four Corners
Park
Lake
Bull Run
Show Bridge
Pumpkin
Indian Peak
Nubieber
Storage Bins
Water
Bieber Station
Juniper
Well
Creek
Gravel Pit
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FOR: EASON OIL COMPANY
BIEBER GEOTHERMAL AREA
EarthSat
R.7E. R.8E.

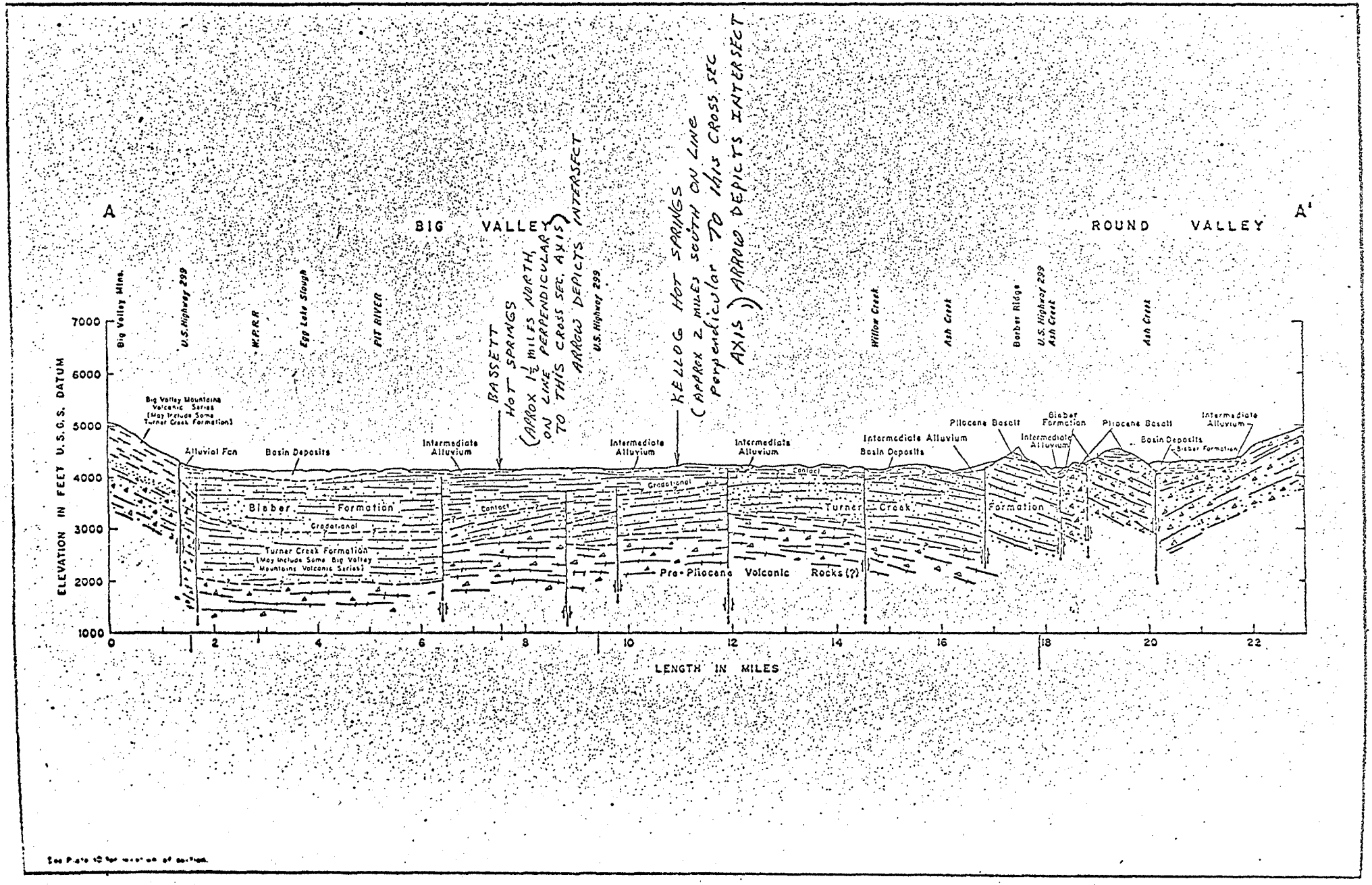
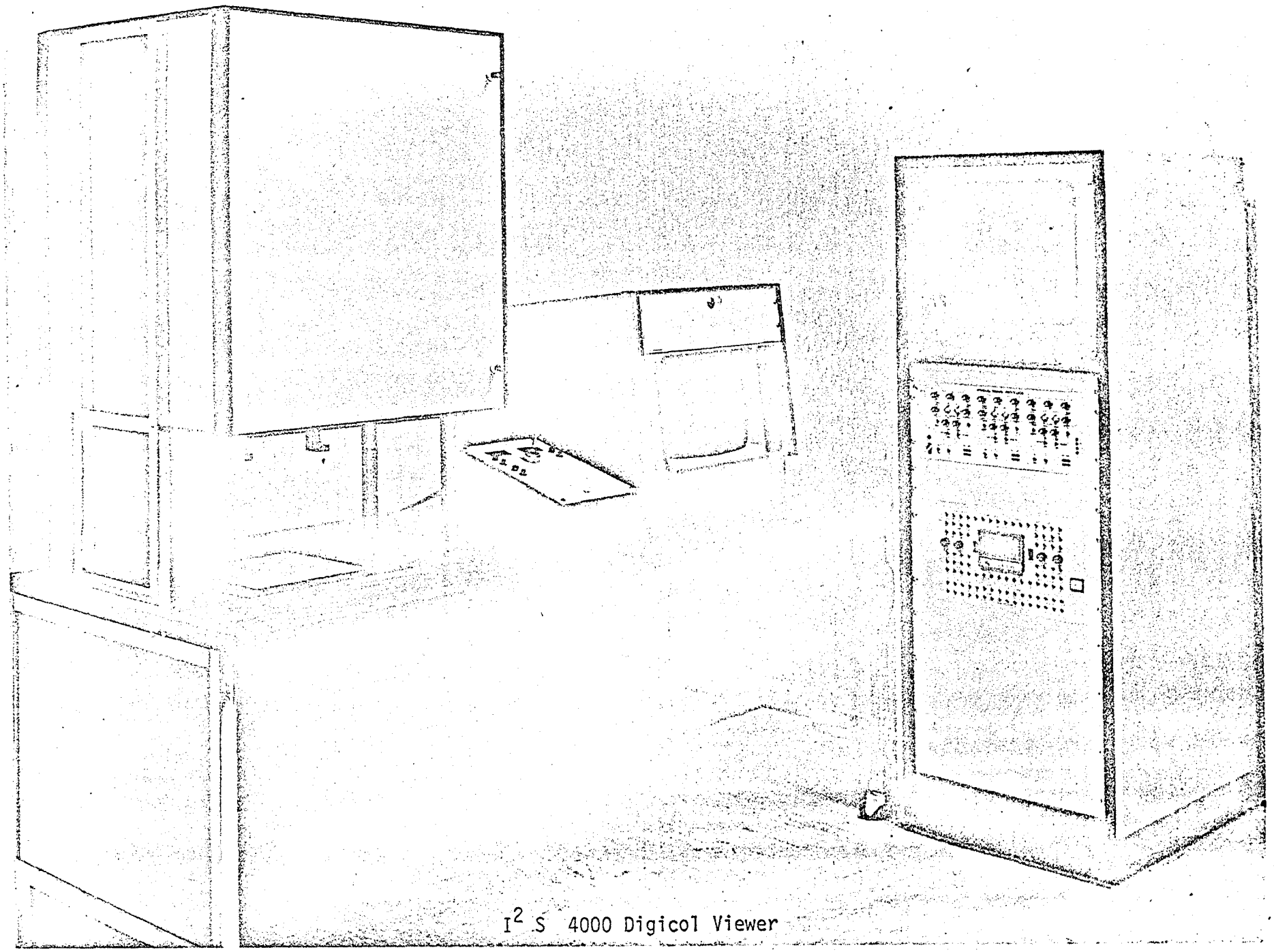


Figure 13. GENERALIZED GEOLOGIC SECTION A-A'
BIG VALLEY AND ROUND VALLEY GROUND WATER BASINS

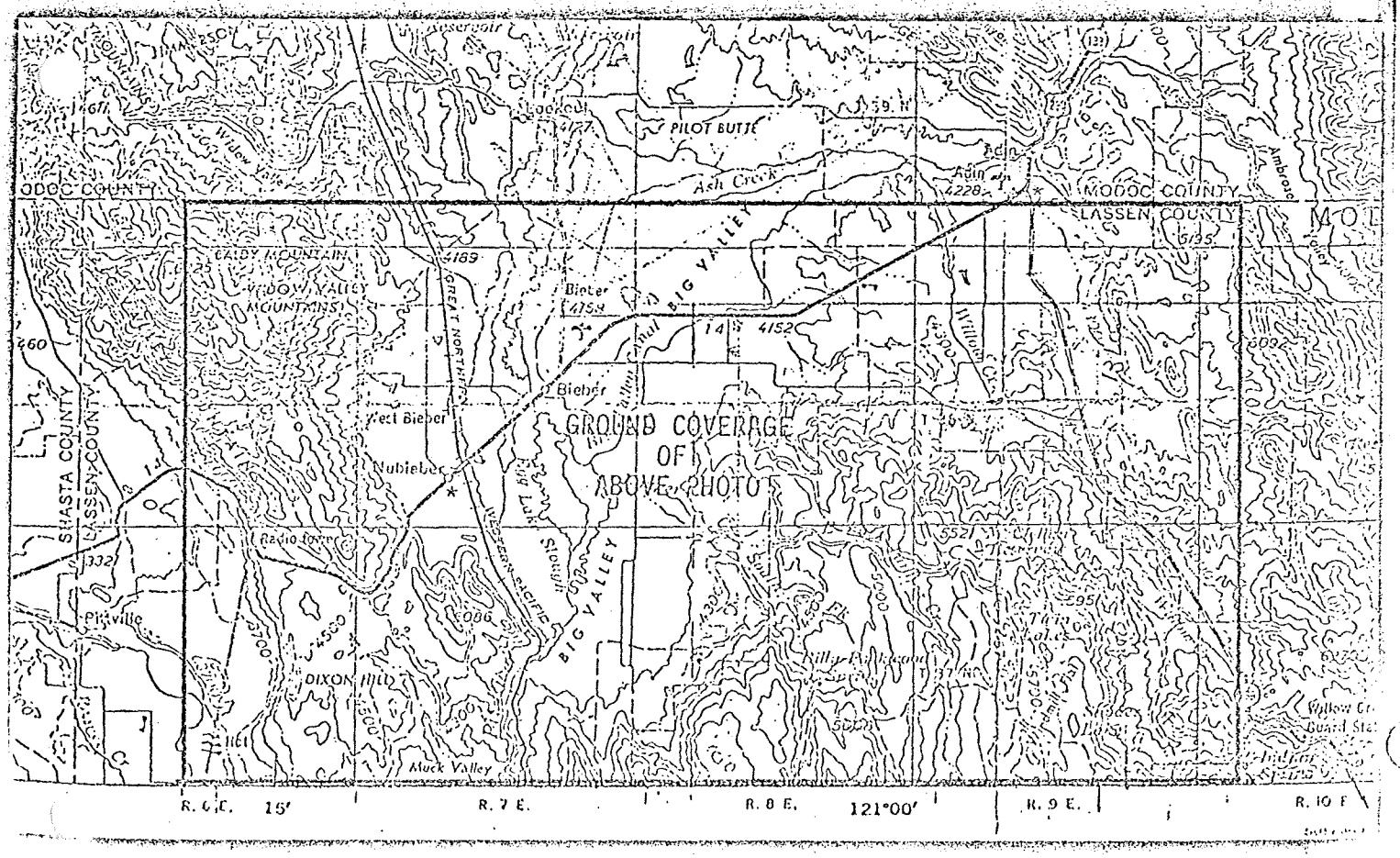
IN BIG VALLEY AND ROUND VALLEY AREA

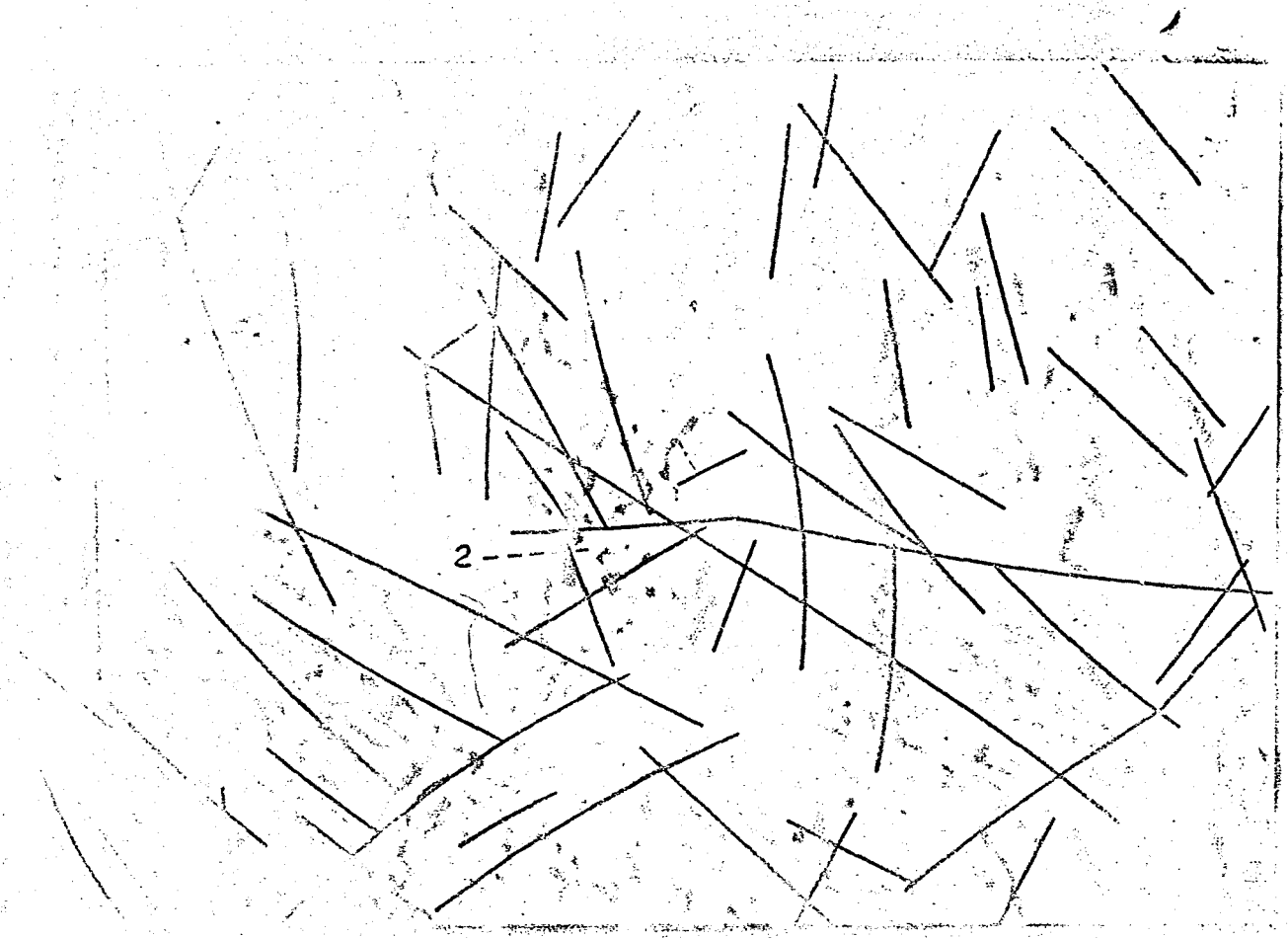
GEOLOGIC AGE			GEOLOGIC FORMATION	STRATIGRAPHY	APPROXIMATE THICKNESS IN FEET	PHYSICAL CHARACTERISTICS	WATER-BEARING CHARACTERISTICS
CENOZOIC	QUATERNARY	RECENT	BASIN DEPOSITS	Qb (Ql)	0-150	Qb: Unconsolidated, interbedded silt, clay, and organic muck. Alkali may be present.	Low permeability. Yields small amounts of water to wells.
			INTERMEDIATE ALLUVIUM	Qal	0-150	Qal: Unconsolidated, poorly sorted silt and sand containing minor amounts of clay and gravel. Alkali may be present.	Moderately permeable. Yields moderate quantities of water to wells.
			ALLUVIAL FANS	Qf (Qc)	0-150	Qf: Unconsolidated, rudely stratified gravel, sand, and silt, with clay lenses.	Moderately permeable; may contain moderate amounts of [illegible] and confined water.
		PLEISTOCENE	PLEISTOCENE BASALT	Qpvb (Pvb)	50-150	Qpvb: Highly jointed, vesicular, flat-lying olivine basalt flows; contains scoria zones.	Permeability ranges from moderate to high. Acts as recharge area for ground water in Big Valley. Yields moderate to large quantities of free and confined water to wells in southern part of Big Valley.
			BIEBER FORMATION	TQb	0-1,000	TQb: Unconsolidated to semi-consolidated, interbedded diatomite, silt, sand, and some gravel. Apparently grades downward into Turner Creek formation.	Generally of moderate permeability. Yields moderate quantities of water to wells.
	TERTIARY	PLIOCENE	PLIOCENE VOLCANIC ROCKS — BASALT	Tpvb	1,000	Tpvb, Tpva: Flows of jointed basalt and andesite.	Moderately permeable. Basalt acts as forebay for recharge to adjacent parts of Big Valley and Round Valley. Yields moderate quantities of water to wells. Andesite is essentially impermeable.
			PLIOCENE VOLCANIC ROCKS — ANDESITE	Tpva			
		MIOCENE TO PLIOCENE	RHYOLITE	Tvr	?	Tvr: Light-colored rhyolite and rhyolite tuff.	Essentially impermeable.
			BIG VALLEY MOUNTAINS VOLCANIC SERIES	Tvb	4,000	Tvb: Jointed, dipping flows of basalt with interbeds of sand, tuff, and diatomite. May be equivalent in part to Turner Creek formation.	Low overall permeability. Some basalt flows may yield small to moderate amounts of water.
		MIOCENE	TURNER CREEK FORMATION	Tmtc	4,000	Tmtc: Well bedded sand, silt, diatomite, tuff, and mudflows; minor flows of basalt, andesite.	Generally low permeability but contains some permeable beds which yield small to moderate quantities of water to wells.



I^2S 4000 Digicol Viewer

FALSE COLOR ENHANCEMENT
OF
INFRARED SCANNER DATA





BIEBER
EDGE ENHANCEMENT OF
INFRARED SCANNER DATA

EXPLANATION OF POINTS ON
FIGURE PHOTOS 11, 12, and 13

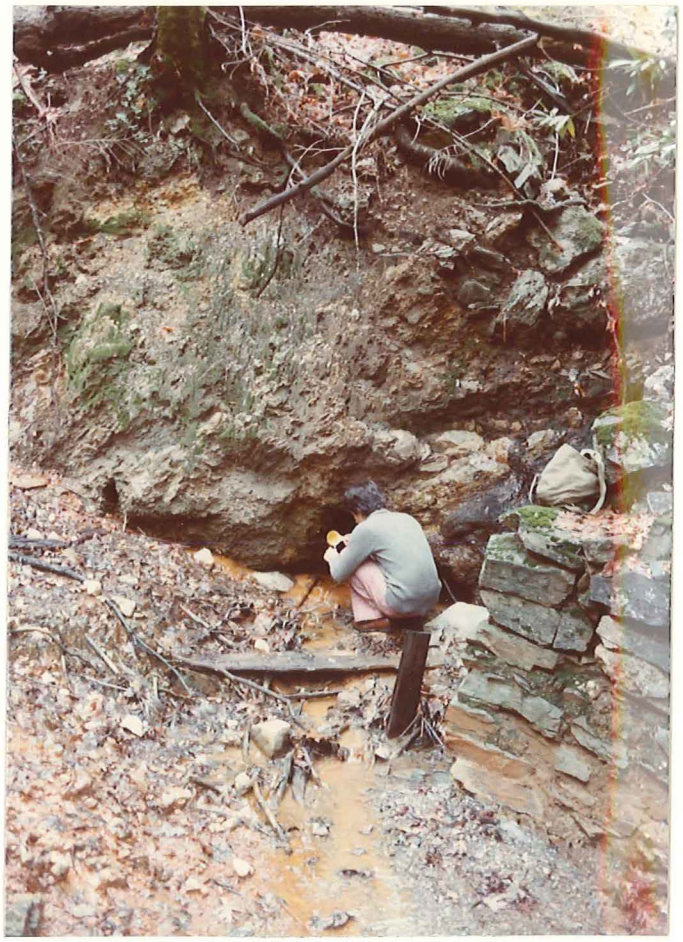
#1 BIEBER

#2 HOT GROUND

#3 BASSETT HOT SPRINGS

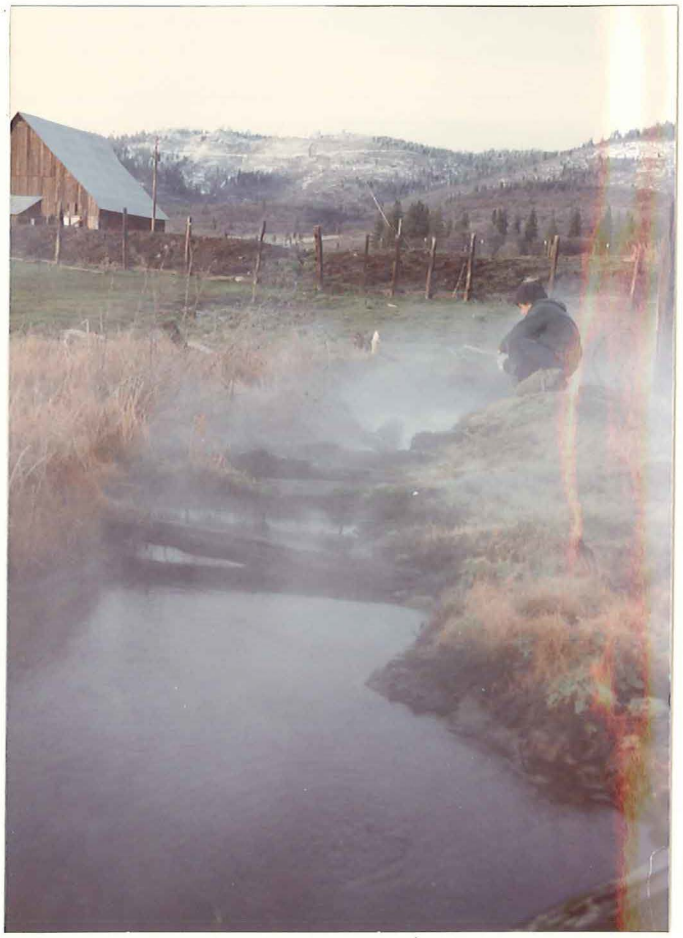
#4 HIGHWAY 299

Rickman 5 pgs.
Bieber, CA



73-12-5

Kellog Hot Spgs, CA



13-12-3

Kellog Hot Spring

73-11½-18

73-11½-19

Richman Spring

FEB • 74

1

73-11½-20

Vestal Spring

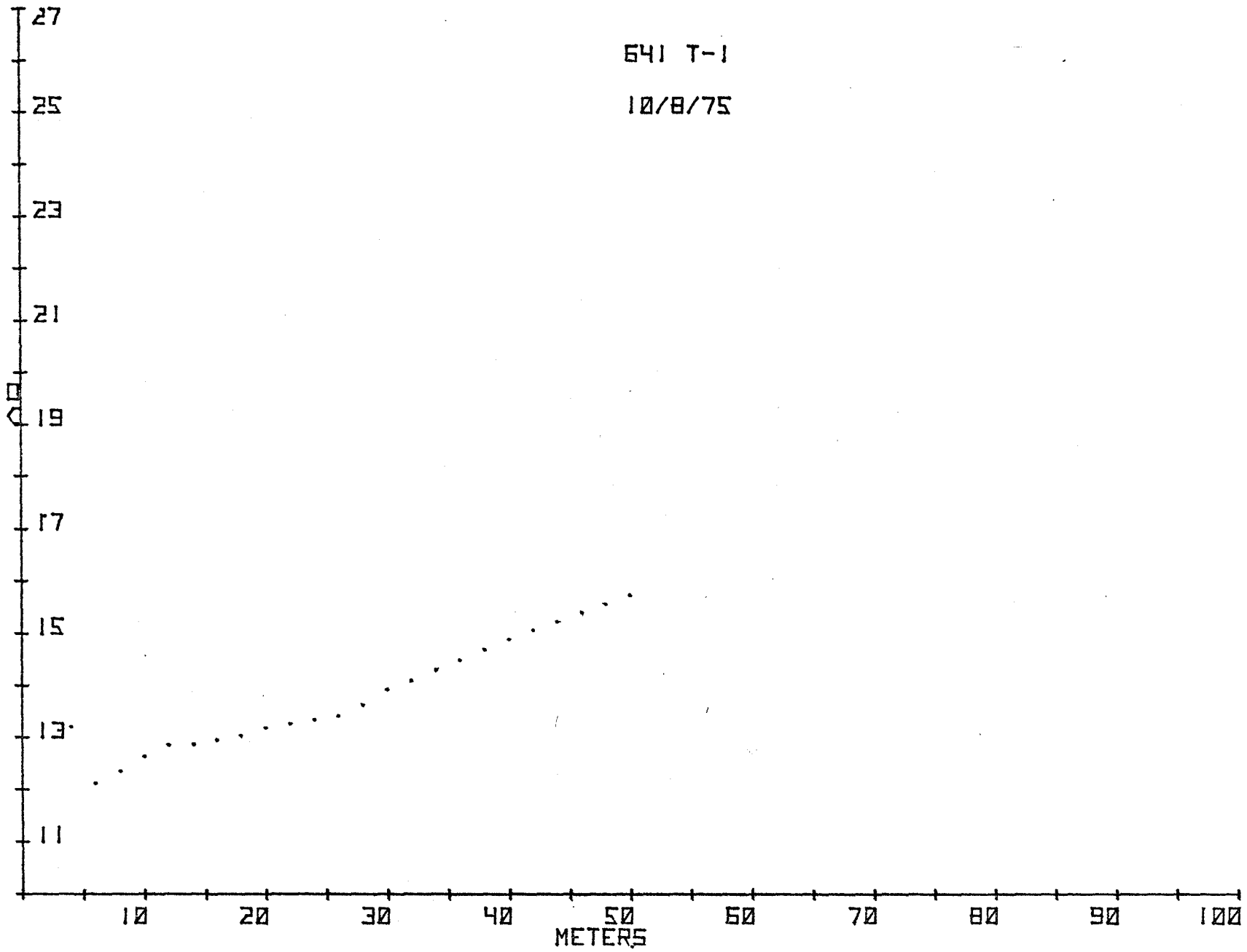
1

73-11½-21

BIEBER, CALIF.

TEMPERATURE VS DEPTH LOG FOR WELL-641 T-1
10/8/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	17.26	-2022.5
4	13.215	-542.5
6	12.13	115
8	12.36	135
10	12.63	112.5
12	12.855	?.5
14	12.87	40
16	12.95	42.5
18	13.035	75
20	13.185	40
22	13.265	40
24	13.345	37.5
26	13.42	102.5
28	13.625	140
30	13.905	100
32	14.105	97.5
34	14.3	95
36	14.49	100
38	14.69	100
40	14.89	85
42	15.06	87.5
44	15.235	85
46	15.405	80
48	15.565	87.5
50	15.74	314.8


641 T-1
10/8/75
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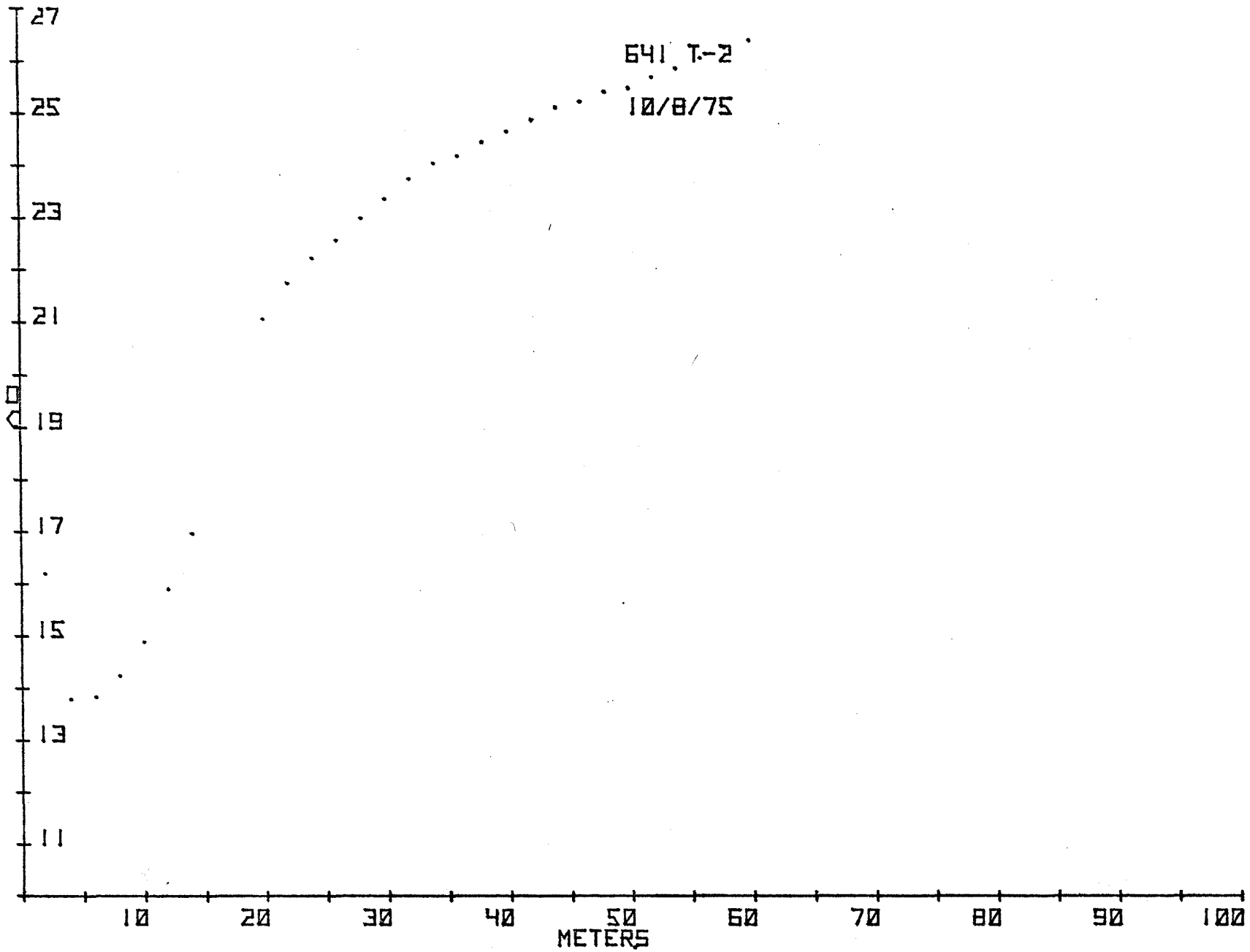
80
90
100
METERS

TEMPERATURE VS DEPTH LOG FOR WELL-641 T-2
10/8/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	16.21	-1200
4	13.81	15
6	13.84	200
8	14.24	325
10	14.89	502.5
12	15.895	532.5
14	16.96	682.5
20	21.055	340
22	21.735	242.5
24	22.22	167.5
26	22.555	217.5
28	22.99	182.5
30	23.355	192.5
32	23.74	147.5
34	24.035	75
36	24.185	127.5
38	24.44	105
40	24.65	110
42	24.87	120
44	25.11	52.5
46	25.215	95
48	25.405	37.5
50	25.48	105
52	25.69	82.5
54	25.855	100
56	26.055	100
58	26.255	62.5
60	26.38	439.6666667


641 T-2
10/8/75
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80
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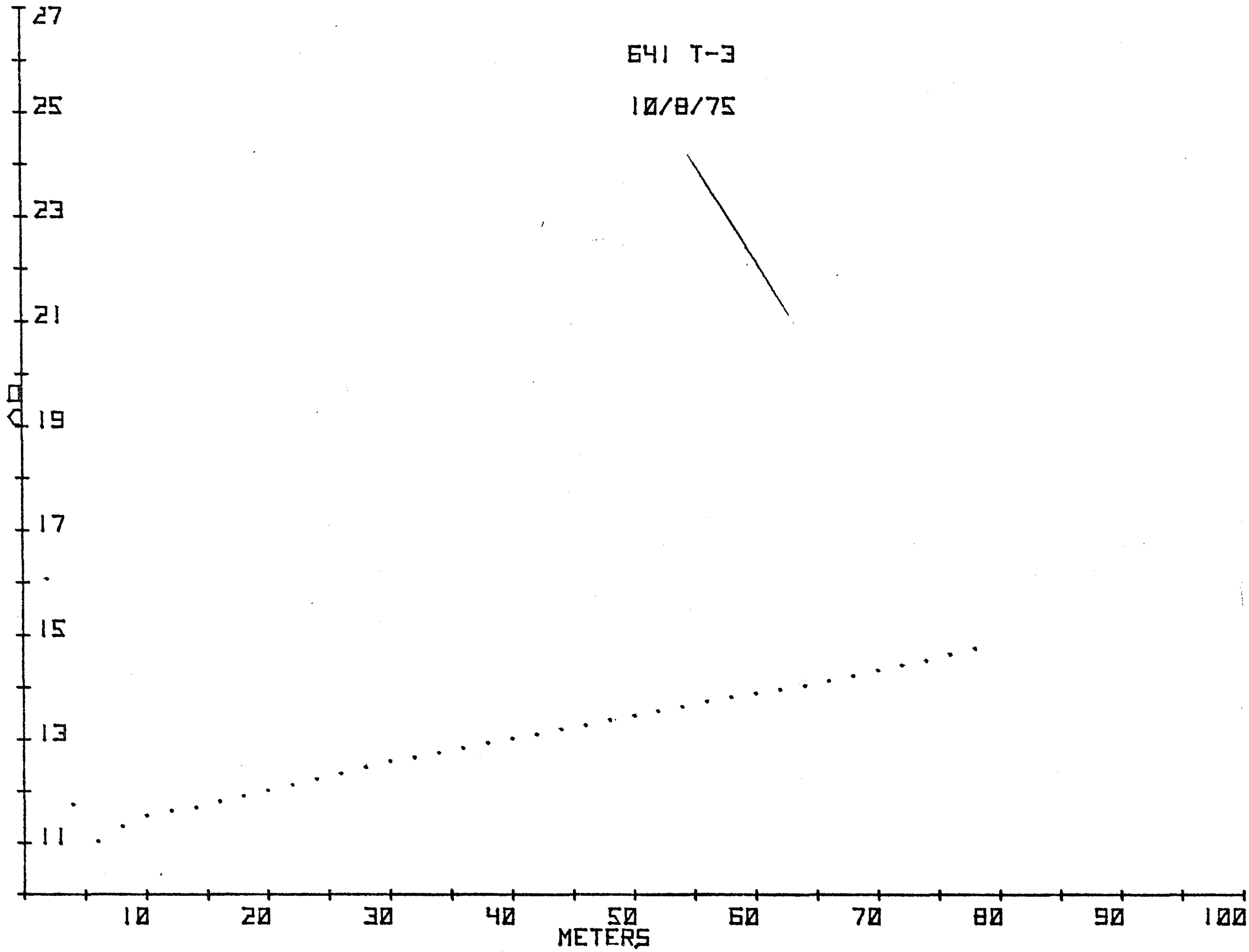
100
METERS

TEMPERATURE VS DEPTH LOG FOR WELL-641 T-3
10/8/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	16.085	-2165
4	11.755	-357.5
6	11.04	145
8	11.33	102.5
10	11.535	50
12	11.635	32.5
14	11.7	50
16	11.8	55
18	11.91	55
20	12.02	60
22	12.14	52.5
24	12.245	52.5
26	12.35	60
28	12.47	60
30	12.59	37.5
32	12.665	47.5
34	12.76	42.5
36	12.845	47.5
38	12.94	40
40	13.02	45
42	13.11	47.5
44	13.205	42.5
46	13.29	45
48	13.38	42.5
50	13.465	45
52	13.555	42.5
54	13.64	47.5
56	13.735	42.5
58	13.82	37.5
60	13.895	37.5
62	13.97	37.5
64	14.045	42.5
66	14.13	50
68	14.23	55
70	14.34	47.5
72	14.435	45
74	14.525	52.5
76	14.63	62.5
78	14.755	189.1666667


641 T-3
10/8/75
METERS
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TEMPERATURE VS DEPTH LOG FOR WELL-641 T-4
10/8/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	15.99	-195
4	12.08	-52.5
6	11.975	47.5
8	12.07	47.5
10	12.165	20
12	12.205	45
14	12.295	35
16	12.365	45
18	12.455	27.5
20	12.51	62.5
22	12.635	37.5
24	12.71	35
26	12.78	32.5
28	12.845	55
30	12.955	32.5
32	13.02	32.5
34	13.085	57.5
36	13.2	32.5
38	13.265	52.5
40	13.37	37.5
42	13.445	37.5
44	13.52	50
46	13.62	62.5
48	13.745	40
50	13.825	40
52	13.905	62.5
54	14.03	67.5
56	14.165	37.5
58	14.24	57.5
60	14.355	77.5
62	14.51	60
64	14.63	52.5
66	14.735	97.5
68	14.93	65
70	15.06	80
72	15.22	82.5
74	15.385	62.5
76	15.51	62.5
78	15.635	77.5
80	15.79	112.5
82	16.015	62.5
84	16.14	50
86	16.24	100
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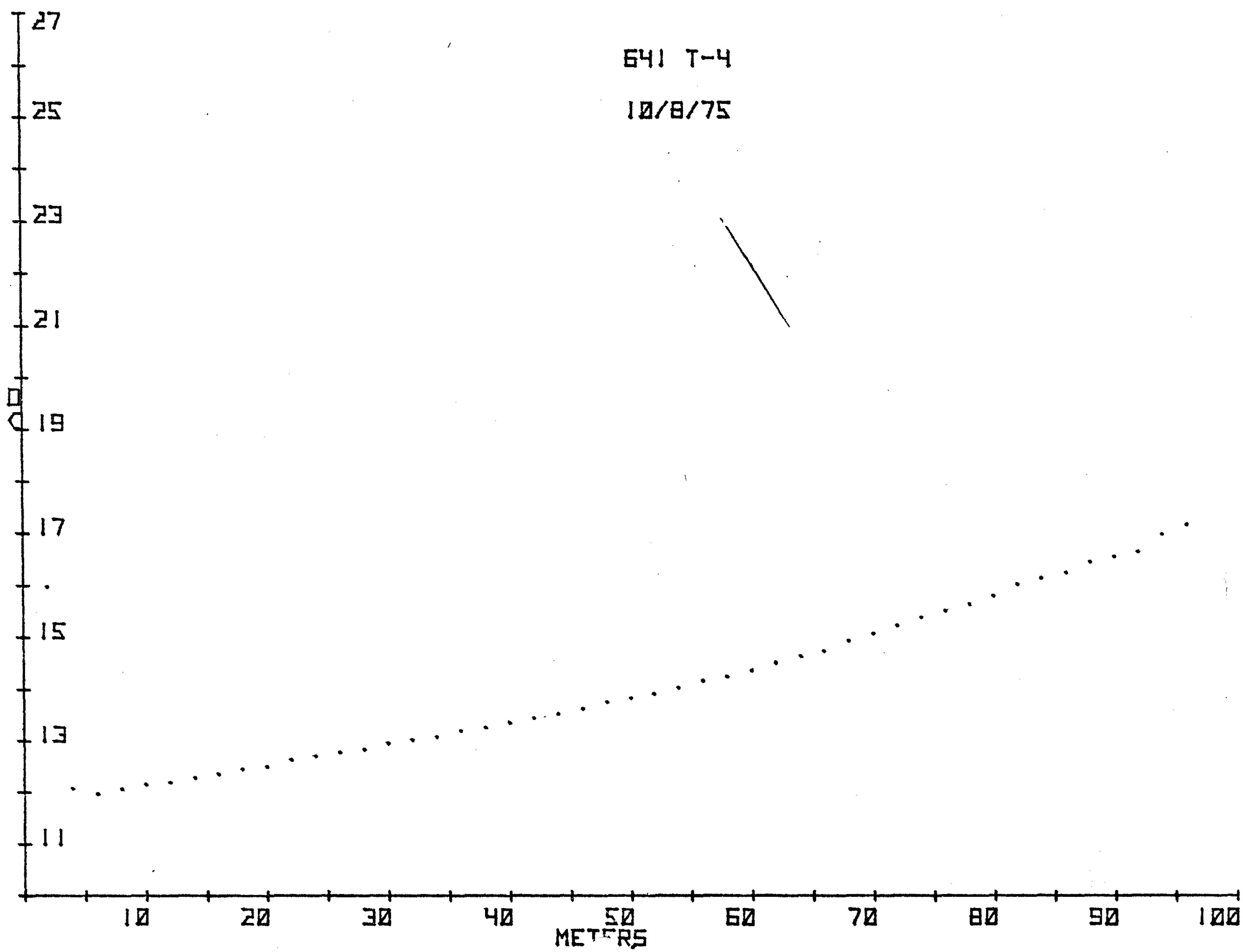
90	16.55	45
92	16.64	167.5
94	16.975	92.5
96	17.16	178.75


641 T-4
10/8/75
°C
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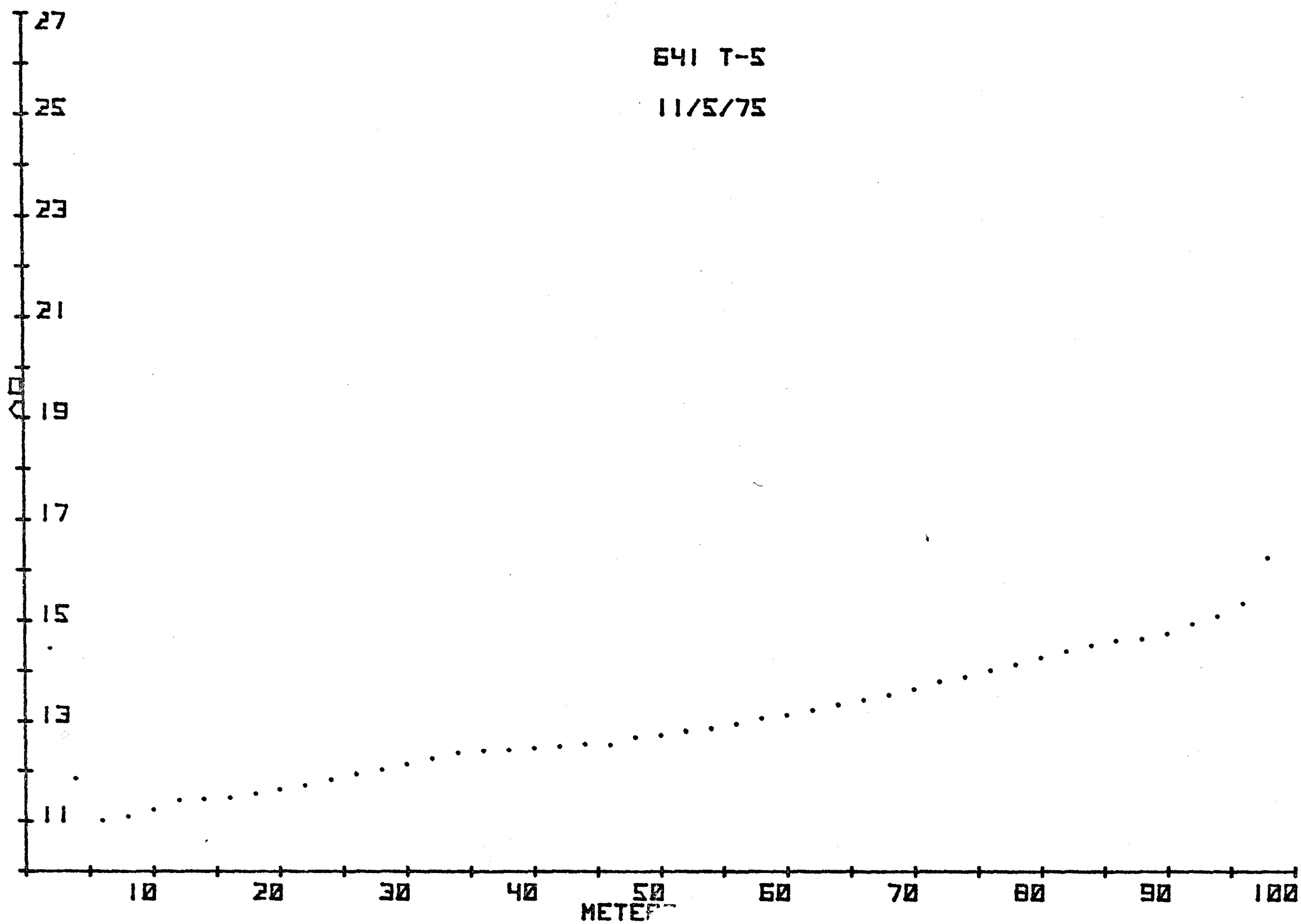
100
METERS

TEMPERATURE VS DEPTH LOG FOR WELL--641 T-5
11/5/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	14.465	-1302.5
4	11.86	-420
6	11.02	37.5
8	11.095	70
10	11.235	97.5
12	11.43	10
14	11.45	17.5
16	11.485	37.5
18	11.56	42.5
20	11.645	37.5
22	11.72	52.5
24	11.825	52.5
26	11.93	47.5
28	12.025	55
30	12.135	52.5
32	12.24	57.5
34	12.355	22.5
36	12.4	10
38	12.42	17.5
40	12.455	20
42	12.495	22.5
44	12.54	-12.5
46	12.515	80
48	12.675	20
50	12.715	42.5
52	12.8	27.5
54	12.855	40
56	12.935	60
58	13.055	32.5
60	13.12	50
62	13.22	55
64	13.33	42.5
66	13.415	52.5
68	13.52	57.5
70	13.635	77.5
72	13.79	37.5
74	13.865	67.5
76	14	57.5
78	14.115	65
80	14.245	65
82	14.375	57.5
84	14.49	50
86	14.59	17.5
88	14.625	52.5
90	14.73	95
92	14.92	77.5
94	15.075	125
96	15.325	455
98	16.235	165.6632653


641 T-5
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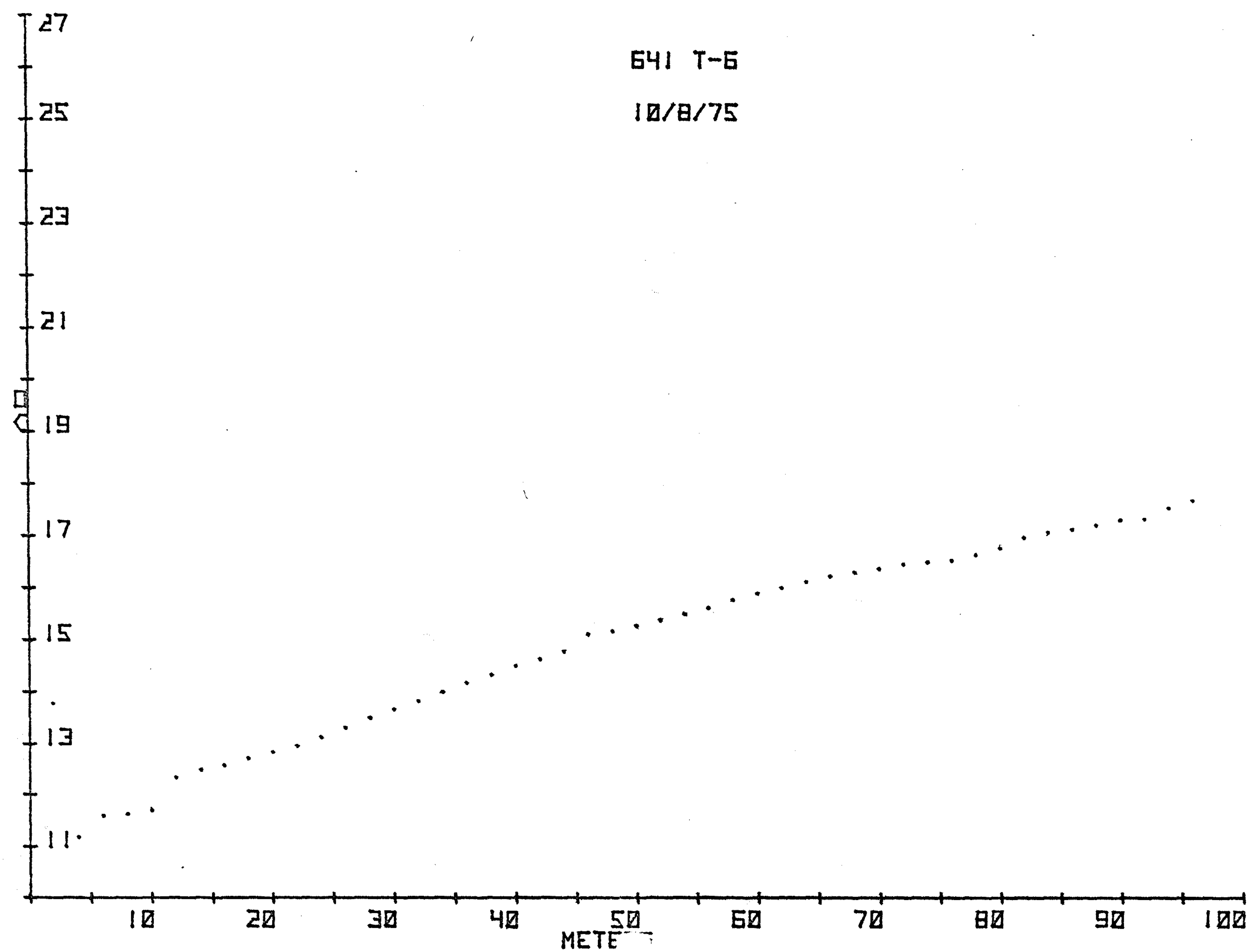
TEMPERATURE VS DEPTH LOG FOR WELL-641 T-6
10/8/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	13.79	-1297.5
4	11.195	200
6	11.595	20
8	11.635	37.5
10	11.71	315
12	12.34	75
14	12.49	45
16	12.58	67.5
18	12.715	60
20	12.835	65
22	12.965	85
24	13.135	90
26	13.315	92.5
28	13.5	80
30	13.66	82.5
32	13.825	90
34	14.005	82.5
36	14.17	77.5
38	14.325	85
40	14.495	65
42	14.625	72.5
44	14.77	170
46	15.11	27.5
48	15.165	52.5
50	15.27	60
52	15.39	55
54	15.5	57.5
56	15.615	75
58	15.765	60
60	15.885	55
62	15.995	62.5
64	16.12	47.5
66	16.215	37.5
68	16.29	37.5
70	16.365	40
72	16.445	20
74	16.485	20
76	16.525	47.5
78	16.62	70
80	16.76	97.5
82	16.955	52.5
84	17.06	27.5
86	17.115	40
88	17.195	50
90	17.295	12.5
92	17.32	105
94	12.53	75
96	17.68	184.1666667



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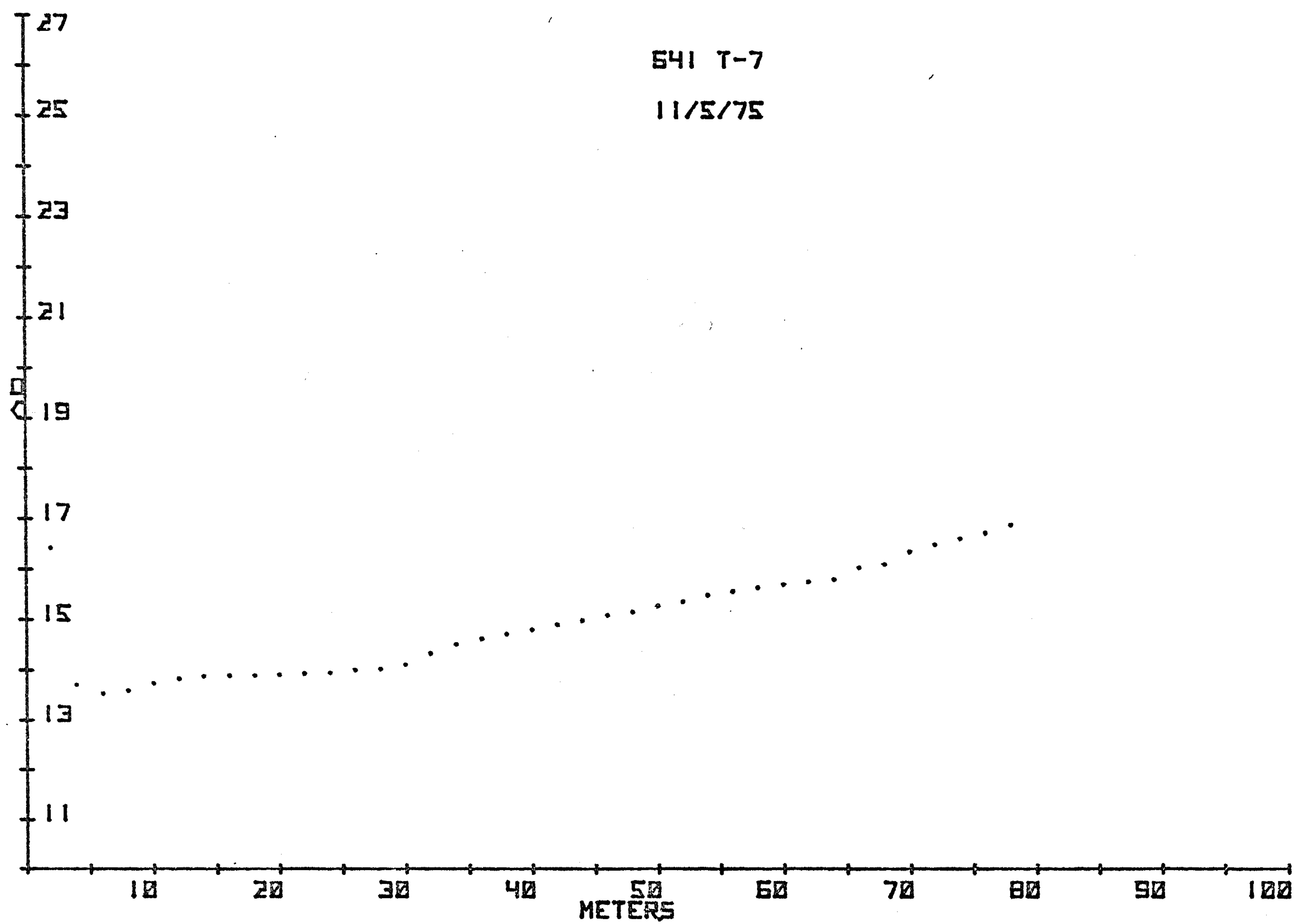
TEMPERATURE VS DEPTH LOG FOR WELL-GIL T-7
11/5/75

DEPTH METERS	TEMPERATURE DEGREES C	GRADIENT C/KM
2	16.435	-1357.5
4	13.72	-90
6	13.54	27.5
8	13.595	72.5
10	13.74	50
12	13.84	65
14	13.89	10
16	13.91	0
18	13.91	2.5
20	13.915	12.5
22	13.94	5
24	13.95	27.5
26	14.005	10
28	14.025	45
30	14.115	107.5
32	14.33	90
34	14.51	57.5
36	14.625	50
38	14.725	40
40	14.805	47.5
42	14.9	45
44	14.99	52.5
46	15.095	37.5
48	15.17	57.5
50	15.285	47.5
52	15.38	57.5
54	15.495	40
56	15.575	32.5
58	15.64	32.5
60	15.705	27.5
62	15.76	25
64	15.81	112.5
66	16.035	35
68	16.105	122.5
70	16.35	75
72	16.5	57.5
74	16.615	57.5
76	16.73	75
78	16.88	216.4102564



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