GL02364

KEPLINGER and Associates, inc.—
INTERNATIONAL ENERGY CONSULTANTS

3430 ENTEX BUILDING
1200 MILAM STREET
HOUSTON, TEXAS 77002
AREA 713/651-3127
CABLE: KEPPET TELEX: 762-324

INTERIM EVALUATION OF EXPLORATION AND DEVELOPMENT STATUS, GEOTHERMAL POTENTIAL AND ASSOCIATED ECONOMICS OF DIXIE VALLEY, NEVADA

FOR

MILLICAN OIL COMPANY

HOUSTON, TEXAS

SEPTEMBER 1, 1978

CONTENTS

KEPLINGER and Associates, inc.

ILLUSTRATIONS

PLATES

Page

FIGURES

Page

FIGURES (Cont'd.)

Page

TABLES

Page

TABLES (Cont'd.)

INTERIM EVALUATION
OF
EXPLORATION AND DEVELOPMENT STATUS,
GEOTHERMAL POTENTIAL
AND
ASSOCIATED ECONOMICS
OF
DIXIE VALLEY, NEVADA

I. SUMMARY

Millican Oil Company has a dominant land position in Dixie Valley, Nevada and presently holds or controls approximately 54,000 federal acres over a highly prospective, but untested, geothermal reservoir. During late 1977, Millican Oil Company joined Southland Royalty Company in a joint exploration program involving multi-level aeromagnetic surveys, magnetotelluric surveys, thermal-gradient drilling (to 1,500 feet T.D.), and hot-spring geochemical monitoring.

The aeromagnetic surveys have outlined structural relationships that differ radically from the normal basin-and-range structures. The surveys have identified two areas with abnormal gradient, one on the western boundary of Dixie Valley and one on the eastern boundary. A follow-up magnetotelluric survey indicated three relatively shallow heat sources (ranging from approximately 20,000 feet to 26,000 feet) on the western boundary and three overlying conductive (low resistivity) anomalies that suggest high fluid temperatures. Two of the three anomalies occur within Millican Oil holdings. Both were drilled to 1,500 feet T.D. to evaluate the overlying thermal gradient and stratigraphic relationships in the area. A maximum of 97°C was encountered in one of the holes at 1,500 feet, after penetrating young

valley-fill and lucustrine deposits, a magnetite-rich gabbroic-like unit and a highly-fractured metasedimentary unit to total depth. A second hole was essentially isothermal (51°C maximum) to total depth (1,500'). Hot spring geochemical monitoring indicates, to date, that long-term geochemical variations (?seasonal) do occur and that such variations suggest mixing of recharge water from the Stillwater Range with heated deep reservoir ground water. Geothermetric calculations will therefore be depressed and hence will not indicate actual deep reservoir temperatures at the surface springs sampled.

Millican Oil and Southland Royalty, in cooperation with University of Nevada at Reno, have cooperated in a joint proposal to the U.S. Department of Energy on a project involving exploration and reservoir anaylsis of Dixie Valley. A favorable response has been received and contract negotiations are to begin in the near future. The project is designed to evaluate the hydrogeologic, tectonic and geophysical aspects of Dixie Valley as they relate to its geothermal potential. Drilling up to three deep holes (8,000 feet) is an integral part of the proposed project. The proposal was presented on a fixed-cost basis with cost-sharing provisions.

Recent estimates indicate that Nevada will rank second only to California in growth of installed geothermal electric capacity by 1983. Two areas that are undergoing intensive exploration are Brady Hot Springs, KGRA and Beowawe KGRA, both are within 50 miles of Dixie Valley and exhibit geological characteristics that are also present in Dixie Valley. Using the former as economic guides, their commercial development will strongly influence the viability of Dixie Valley, if the latter can produce comparable reservoir temperature and flow rate.

The economic potential of Brady Hot Springs, Beowawe and Dixie Valley in competition with coal depends to a large extent on cost reductions expected over the next few years from research on development and drilling techniques and materials, as well as from federal tax incentives allowing a 22% depletion allowance, expensing intangible drilling costs and a significant investment tax credit designed to assist the geothermal industry.

Based on resource data from nearby areas and on limited data from the recent exploration program, Dixie Valley appears to have a minimum potential production sufficient to support six 50 MWe power plants over a 30-year period. In addition, an average initial well production of 475,000 pounds/hr. (3.85 MWe/well) at a reservoir temperature of 225°C appears possible at this time. A flash recovery system would be appropriate at such temperature and flow rate. A more accurate assessment of the potential of Dixie Valley, however, can be made only after the proposed deep drilling program has been completed.

II. EXPLORATION PROGRAM

Introduction

During late 1977, Millican Oil Company joined Southland Royalty Company in a joint exploration program over a 300 square-mile area of

Dixie Valley, Nevada. Southland Royalty Company served as operator for the program. The exploration program, however, was developed jointly and costs were shared on a 50-50 basis. All data and subsequent interpretations have been shared. An agreement was made between the two companies that any additional land acquisition prompted by data from the joint exploration program would be acquired and owned jointly. No other relationship exists at this time between Millican Oil Company and Southland Royalty Company, with the exception of joint ownership in 19,200 acres of newly acquired federal land in Dixie Valley.

The exploration program was developed and supervised by Richard L. Jodry, consultant to Southland Royalty Company, and Michael D. Campbell, Keplinger and Associates, Inc., consultants to Millican Oil Company. The program consisted of the following:

Phase I

A. Multi-Level Aeromagnetic Survey by Senturion Sciences, Inc., Tulsa. Completed October, 1977.

B. Scalar and Tensor Magnetotelluric Survey by Senturion Sciences, Inc. Completed February, 1978.

C. Phase II Multi-Level Aeromagnetic Survey by Senturion Sciences, Inc. Completed June, 1978.

D. Reconnaissance Drilling and Temperature Logging Program (up to 1500'TD). Completed September, 1978.

E. Geothermetric Ground-Water Sampling and Regional Data Collection - Periodic Sampling Continuing of Selected Springs Within Dixie Valley Area.

Multi-Level Aeromagnetic Survey - Phase I

Five multi-level aeromagnetic profiles (approximately 50 miles) were flown (at five altitudes) during the fall of 1977 over the western and central parts of Dixie Valley. This highly sensitive technique is used to define faults, throw and dip (where possible) and areas of abnormal gradients (suggesting heated ground water). Preliminary structural relationships were developed by Senturion Sciences, Inc. (see Plate I).

In addition, a major intrusive feature (apparently cold) was identified in T22N, R36E and an area of abnormal magnetic gradient was identified in T24N, R36E.

Two major features of the interpreted structural relationships developed by Senturion Sciences have been challenged. The first feature is the dip direction and relative movement of the "Old Stillwater Fault"; the interpreted aeromagnetic data suggests that the fault, although high angle, has a westward dip component under the Stillwater Range. In a previous report by Keplinger and Associates, Inc. (September 16, 1977), we reported that the pertinent literature and available data concerning the structural setting of Dixie Valley, and our own field evaluations along the range-front fault (referred to by Senturion as the "Old Stillwater Fault") suggest a typical basin-and-range structural setting where tensional stress has predominated as far back as early Tertiary and still predominates the tectonic movements in the Dixie Valley area. We suggested that such conditions require a near vertical and basinward dip (normal) for the range-front fault.

The significance of the dip direction (and relative movement) of the fault in question is of paramount importance in developing the structural relationships within Dixie Valley. The location and characteristics of all faults in the prospective area will guide future geothermal exploration. Very little direct structural information is available in Dixie Valley because the area is covered by coalluvium, alluvium and lucustrine deposits, which obscure the structural picture. Therefore, what little information does exist (e.g. seismic refraction data, range geology, earthquake epicenters, lineaments and other features identified by areal photographic techniques) must be placed within a general model that can be used to extrapolate various known structural features and relationships into areas without data but with possible site-specific geothermal potential. If the Senturion interpretation is correct, and that is possible, the structural model required would involve compressional and vertical tectonics, which differs significantly in general and in detail from a structural model involving tensional tectonics of the so-called "normal" basin-and-range structures.

The second major feature that has been challenged is the interpretation involving the so-called "Stillwater Thrust", as well as the Mud Fault (or part of it). The former feature occurs in a highly prospective area of Dixie Valley. As with the first feature mentioned above, all available information suggests that such a feature is mechanically impossible within a tectonic model involving tensional stress. However, if a compressional model were involved, such a thrust would not only be possible but also probable in such a tectonic environment. Alternate interpretation of the aeromagnetic data is nevertheless required at this time before the deep well-site selection process is begun. Some of the alternate interpretations are discussed in the following review of aeromagnetic data.

Interpretation of multi-level aeromagnetic data depend upon the migration of a particular magnetic characteristic, as indicated by multi-level flight lines, to calculate the dip component of a fault. However, we suggest that the magnetic characteristics used to define dip may or may not represent faulting. Such characteristics do, however, represent zones of magnetic discontinuity. Such discontinuities could develop above a relatively shallow heat source where excessive heat has altered the ferrimagnetic rocks in such a manner that a zone interpreted as a fault may in fact be a boundary between ferrimagnetic and paramagnetic rocks. The fault zone, if known to be present, may not be apparent under such conditions. The magnetic characteristics used for fault identification may have been affected by alteration. The shape of a zone of magnetic discontinuity would be in the form of an inverted cone, assuming the heat source is circular in horizontal dimension. If the heat source is fault-controlled at depth, the zone would be in the form of an irregular, elongate prism with an irregular apex upward, which would be expected in the Dixie Valley area.

Interpretation of multi-level aeromagnetic data, especially those derived from surveys with high-response capability, also depend upon variations in gross rock magnetism to identify separate geologic units. However, magnetic variations are created by a number of geothermal and geologic features, some of which are:

1. Heating above Curie point of a geologic unit of presumed uniform ferrimagnetic content, thereby allowing the inference that where "significant" magnetic lows occur, heating and, therefore, geothermal activity has occurred. Some lows that appear within areas of higher magnetics are characterized as having "abnormal" gradients.

2. A ferrimagnetic unit in contact with a paramagnetic unit is a common relationship. This contact may be a high-angle intrusive contact but (based on magnetic data) could be interpreted as a fault in Dixie Valley; the former would be expected (e.g. high-ferrimagnetic gabbro in contact with a low-ferrimagnetic volcanic or metasedimentary unit).

3. Detectable ferrimagnetic variations within the same unit, if of sufficient magnitude, may also appear to be faults, but in magnetic data may show systematic variation, which would not be uncommon.

4. Detectable ferrimagnetic variations between different units at the same elevation may also appear as faults (similar to 2) based on magnetic data. This condition would also be expected in Dixie Valley as indicated by the complex mosaic outcrop pattern consisting of many different units exposed in the Stillwater and Clan Alpine Ranges. Conditions should not be different below the cover material in Dixie Valley.

It should be apparent that the applicability of all the multi-level aeromagnetic interpretations has been challenged. However, where independent data support the aeromagnetic interpretations, such integrated interpretations can be accepted with reasonable confidence that they are accurate within reasonable limits. For example, the following interpretations do have independent support:

1. The range-front fault (Old Stillwater Fault) is shown to have major displacement, although the indicated strike and dip are questioned.

2. The Marsh Fault is accepted, supported by tensional model, by the anomalous western boundary of Humbolt Salt Marsh, and by the position of two microearthquake clusters along strike of of the Marsh Fault. It may be offset faulted between flight lines B and C. (see Plate I)

3. The Buck Brush Fault is accepted, supported by tensional model and by the anomalous occurrence of springs along the strike of fault. Relative movement consistent.

4. The Bernice Creek Fault is accepted, supported by relative movement and correlated with major fault trend in Stillwater Range, which traverses Dixie Valley.

5. The "Gabbro" Intrusive is accepted; such a unit must have a striking magnetic character.

6. The Dyer Fault is accepted, supported by known fault scarplet with same strike direction in area. Relative movement is consistent.

7. Area of abnormal gradient is accepted only because it was confirmed by the magnetotelluric survey, discussed later in this report.

Multi-level aeromagnetic surveys do not generate unique solutions. If pertinent data can be marshalled, as is the case with many of the Senturion interpretations, to support some of the critical aeromagnetic interpretations challenged herein, the development of structural relationships within Dixie Valley would be well advanced at this time. However, the very basic academic question of which tectonic model is applicable to the Dixie Valley must be addressed and resolved in the near future. The approach to resolving this question will be discussed later in this report under "U.S. Department of Energy Program".

Scalar and Tensor Magnetotelluric Survey

Twenty-seven scalar magnetotelluric stations (SMT), and one tensor magnetotelluric station (TMT) were occupied. SMT stations recorded one component of the telluric field and the TMT station recorded three components of the telluric field. Audio-magnetotelluric data (AMT) supplied to Senturion Sciences by Keplinger and Associates from earlier U.S. Geological Survey evaluations were integrated with the survey.

SMT and TMT, as well as AMT, are widely used in geothermal exploration with excellent results to date. This survey located three unusually shallow heat source areas (see Plate II) at a depth ranging from 19,600 to 26,000 feet (six to eight km) and three overlying conductive (low resistivity) anomalies, which indicate high fluid temperatures (see Plate II and Figure 1). The two northern areas ("Stillwater" and "Mine"

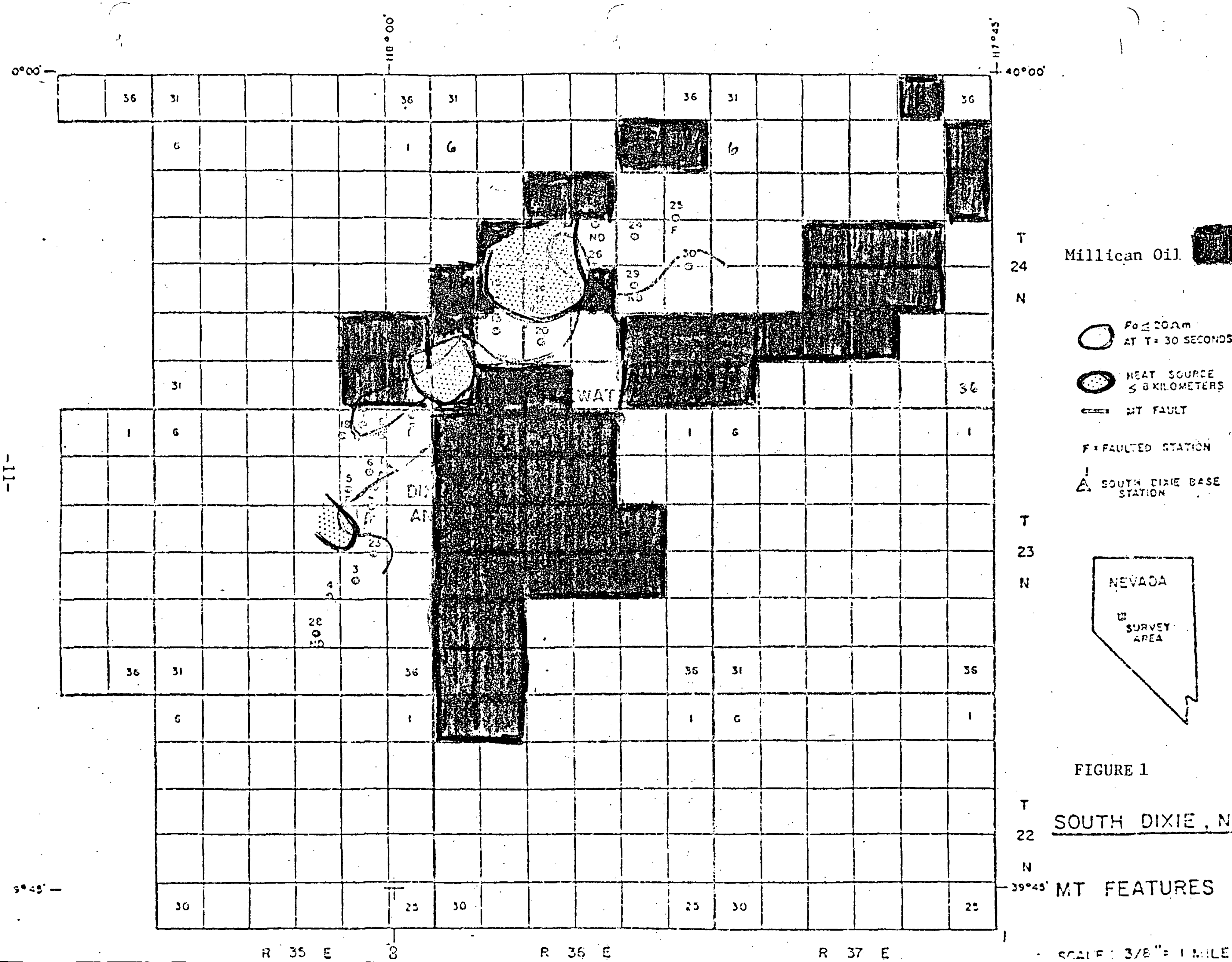


FIGURE 1

SOUTH DIXIE, NEV

MT FEATURES

anomalies) correlate well with areas along the multi-level aeromagnetic profiles which exhibited abnormal gradients. It should be noted that Millican Oil holdings are located, in part, over two of the three heat sources and associated conductive anomalies reported in that survey.

Heat sources are defined as having anomalously low resistivity (1 to 5 ohmeters). Conductive anomalies were derived by plotting and contouring apparent resistivity at selected recorded frequencies. Anomalies were defined as having apparent resistivities of 20 ohmeters at the 30-second period recording frequency. They change location with respect to the frequency recorded. Such variations are a function of depth and suggest changes in fracture pattern, high fluid salinity and/or high fluid temperature. The 10-second period depth representation may indicate maximum drilling depth (see Figure 2). In general, the 1-second recording frequency suggests conditions at a depth of approximately 5,000 feet, the 10-second at 7,000 feet, the 30-second at 12-14,000 feet and the 100-second at greater than 18,000 feet. (See Figures 4, 5, and 6).

The depth from surface to a resistive unit (defined by Senturion Sciences as the gabbroic complex) has been calculated (see Figure 3).

<u>Multi-Level Aeromagnetic Survey - Phase II</u>

Follow up aeromagnetic profiles were flown to tie-in the data obtained during the original survey in an attempt to reevaluate the dip component of the "Old Stillwater Fault". In addition, existing profiles were extended eastward across Dixie Valley to the Clan Alpine Ranges (see Plate I). The hade of the "Old Stillwater Fault"

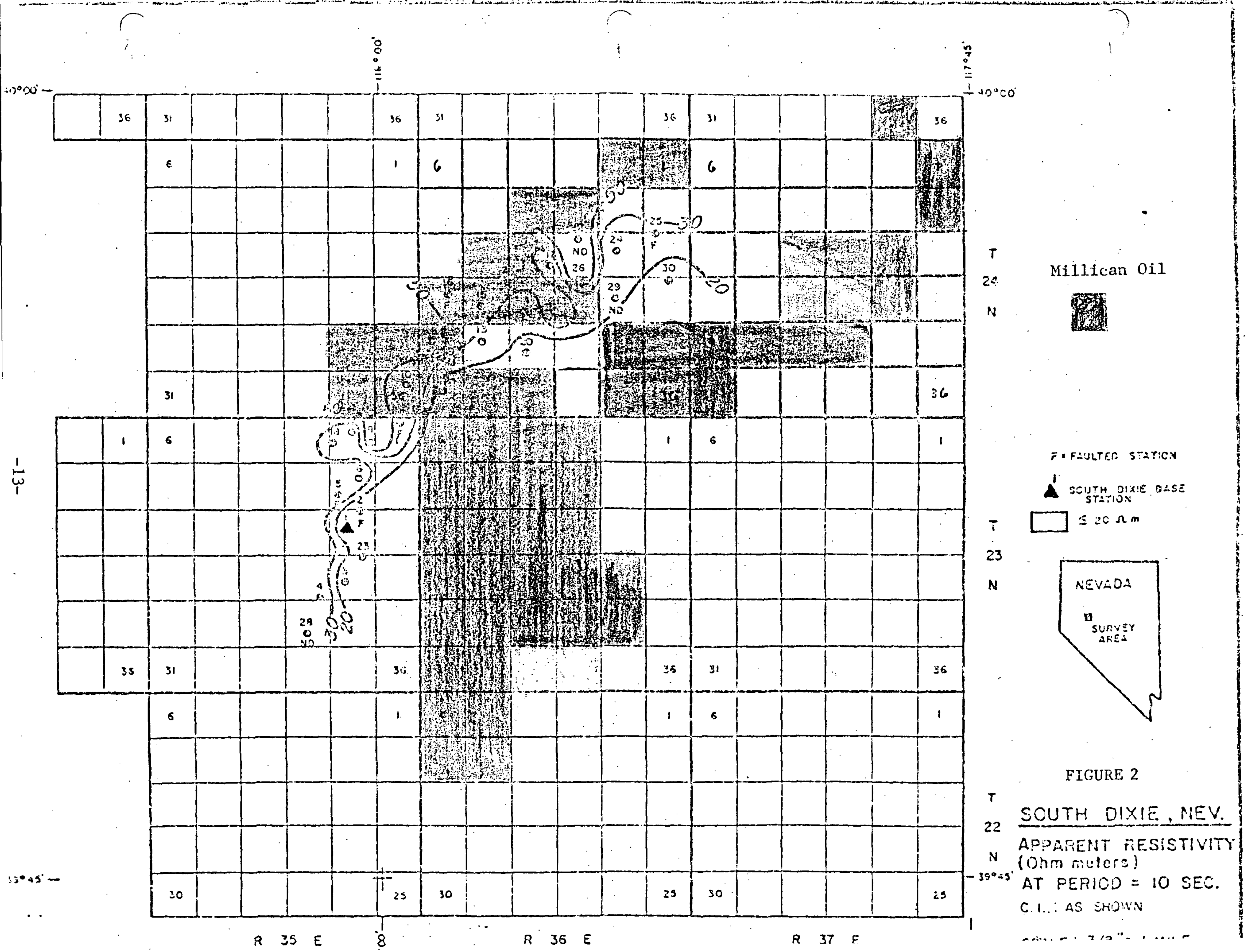


FIGURE 2

SOUTH DIXIE, NEV.

APPARENT RESISTIVITY (Ohm meters) AT PERIOD = 10 SEC.

C.I.: AS SHOWN

-14-

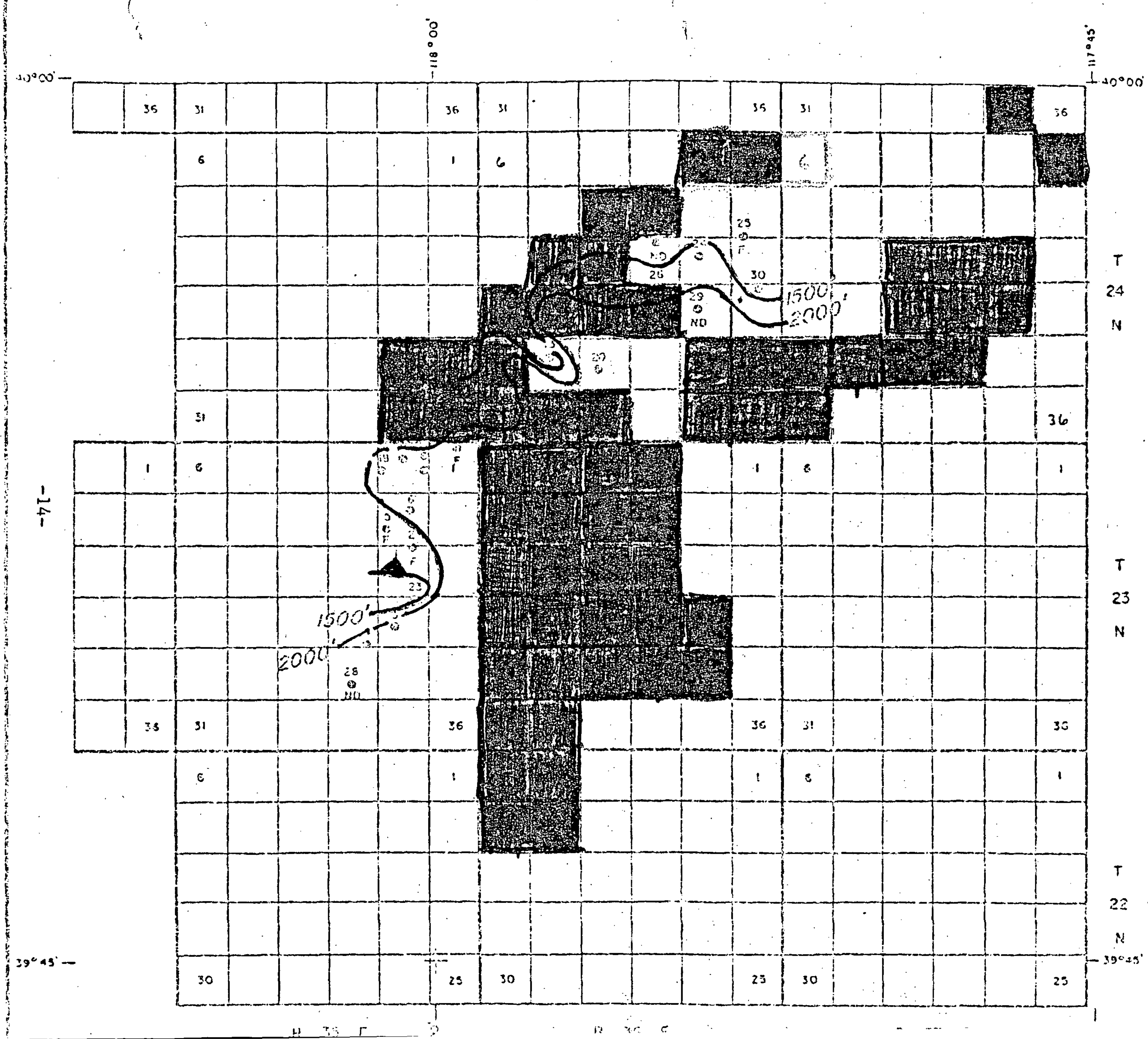


FIGURE 3

SOUTH DIXIE, NEV.

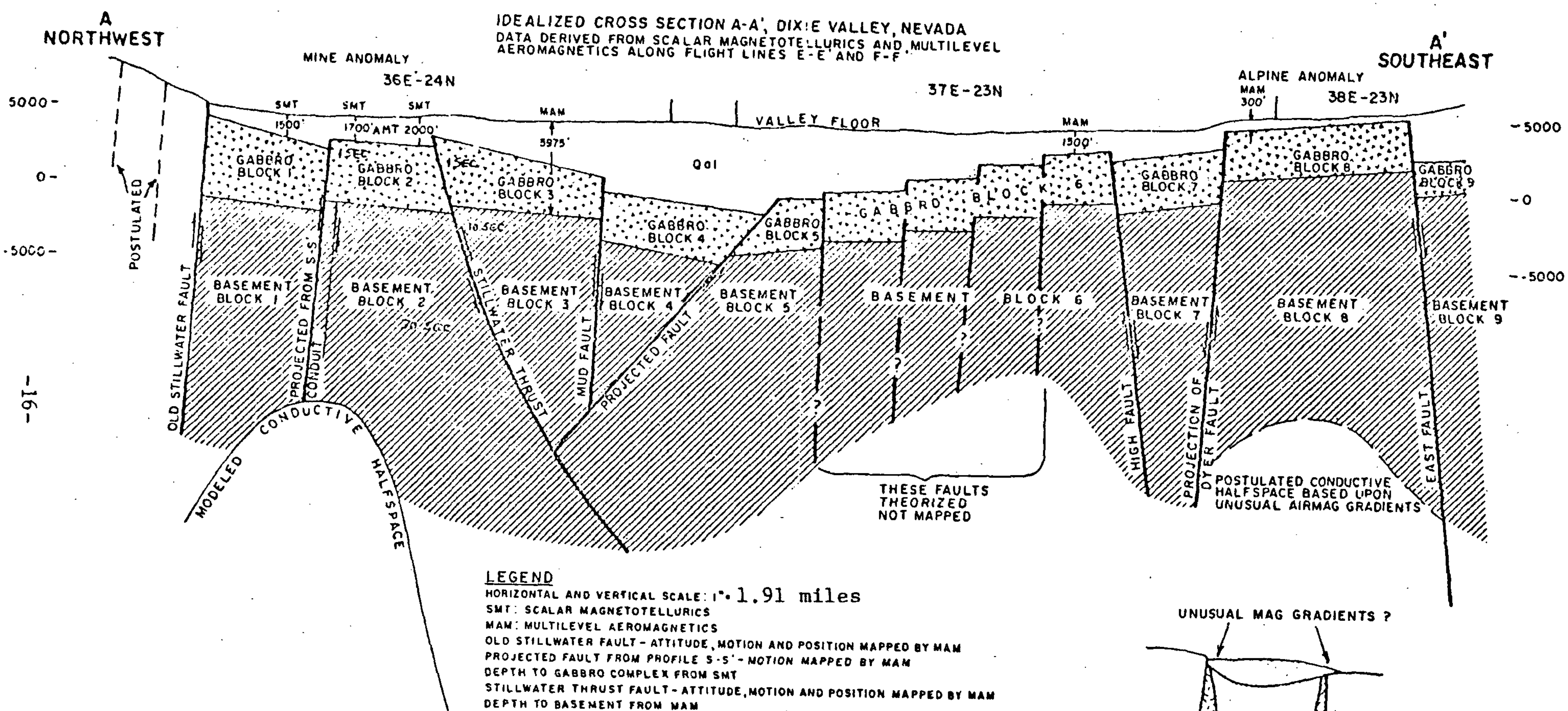
ISOPACH - SURFACE TO RESISTIVE GABBROIC COMPLEX (Feet)

C. I. : AS SHOWN

was reconfirmed as having a reverse relative movement and a dip toward the west. In the eastern profiles a new area was identified as having a significant geothermal potential (see Plate I, Profile F). A four-cycle magnetic high of exceptionally sharp relief was reported at the intersection of Sections 19 and 30, T38N, R23E; Section 24 and 25, T37N, R23E. The anomaly has a range of 558 gammas in three miles. An unusually high magnetic gradient falloff rate east of the magnetic apex (in Section 25, T37N, R23E) has been interpreted as an indication of an abnormal loss of magnetism due to an increase in temperature at relatively shallow depth. However, a ferrimagnetic dike could also be interpreted from the magnetic data, but the associated abnormal gradient still has considerable geothermal potential.

Independent data supporting the eastern anomaly is indirect. A shallow hole (500 feet?) was drilled a few years ago to the north of the anomaly and reportedly had a 5-8° C /100 feet thermal gradient. It should be noted that this is an unconfirmed report. In addition, a resistivity survey a few miles to the southeast also reported very low resistivity (high temperatures) at relatively shallow depths. This also is unconfirmed. A follow-up magnetotelluric survey is merited.

Additional faults have been identified along the eastern border of Dixie Valley. Senturion Sciences was requested to integrate all aeromagnetic and magnetotelluric data and to generate their geological interpretations via cross-sections of Dixie Valley (see Plate III and Figures 4, 5 and 6). The general structural configuration expressed suggests that a compressional model is applicable to this part of Dixie Valley. Figure 7



LEGEND

HORIZONTAL AND VERTICAL SCALE: 1" = 1.91 miles
SMT: SCALAR MAGNETOTELLURICS
MAM: MULTILEVEL AEROMAGNETICS
OLD STILLWATER FAULT - ATTITUDE, MOTION AND POSITION MAPPED BY MAM
PROJECTED FAULT FROM PROFILE S-S' - MOTION MAPPED BY MAM
DEPTH TO GABBRO COMPLEX FROM SMT
STILLWATER THRUST FAULT - ATTITUDE, MOTION AND POSITION MAPPED BY MAM
DEPTH TO BASEMENT FROM MAM
MUD FAULT - ATTITUDE, MOTION AND POSITION MAPPED BY MAM
PROJECTED FAULT FROM A-A' EXTENSION - MOTION MAPPED BY MAM
FOUR SECONDARY FAULTS - THEORIZED
DEPTH TO GABBRO COMPLEX FROM MAM
HIGH FAULT - MOTION AND POSITION MAPPED BY MAM
DYER FAULT - PROJECTED INTO PROFILE - PROBABLY OBSCURED BY UNUSUAL GRADIENTS IN BASEMENT BLOCK 8, MOTION MAPPED BY MAM
DEPTH TO GABBRO COMPLEX FROM MAM
EAST FAULT - MOTION AND POSITION MAPPED BY MAM
SMT CONDUCTIVE ANOMALIES
MODELED CONDUCTIVE HALFSPACE DERIVED FROM SMT
UNUSUAL MAGNETIC GRADIENTS MAPPED BY MAM

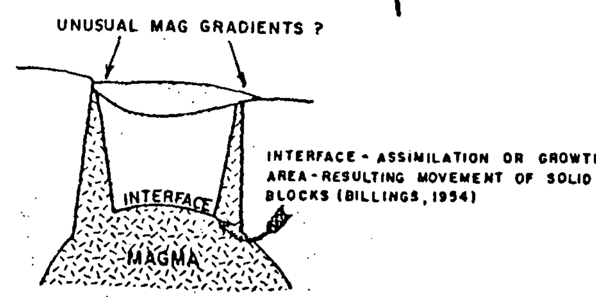
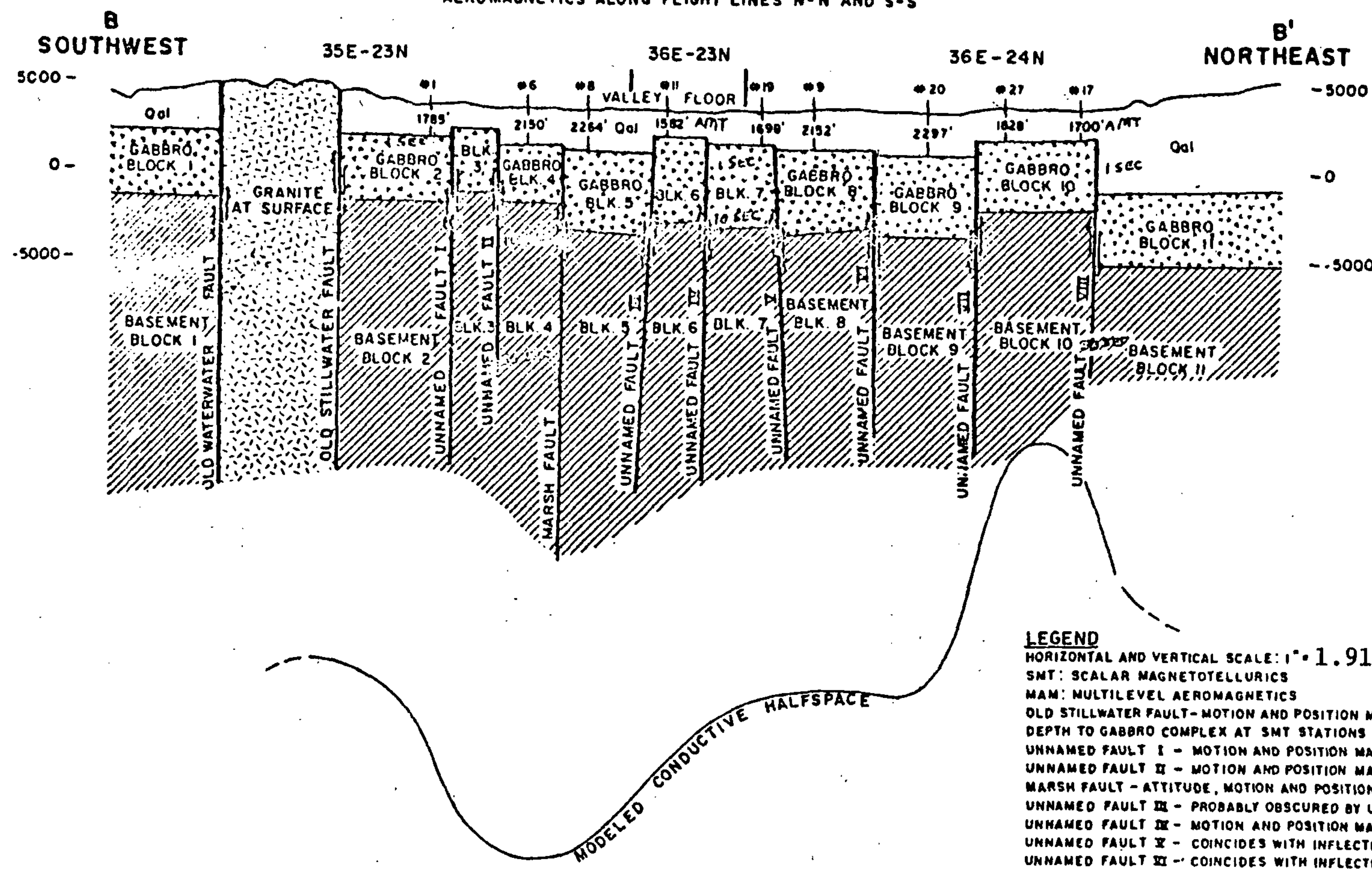


FIGURE 4

IDEALIZED CROSS SECTION B-B', DIXIE VALLEY, NEVADA
DATA DERIVED FROM SCALAR MAGNETOTELLURICS AND MULTILEVEL AEROMAGNETICS ALONG FLIGHT LINES N-N' AND S-S'



LEGEND

HORIZONTAL AND VERTICAL SCALE: 1" = 1.91 miles
SMT: SCALAR MAGNETOTELLURICS
MAM: MULTILEVEL AEROMAGNETICS
OLD STILLWATER FAULT - MOTION AND POSITION MAPPED BY MAM (DETECTED TWICE)
DEPTH TO GABBRO COMPLEX AT SMT STATIONS AS NOTED
UNNAMED FAULT I - MOTION AND POSITION MAPPED BY MAM
UNNAMED FAULT II - MOTION AND POSITION MAPPED BY MAM
MARSH FAULT - ATTITUDE, MOTION AND POSITION MAPPED BY MAM
UNNAMED FAULT III - PROBABLY OBSCURED BY UNUSUAL GRADIENTS IN BASEMENT ALONG FLIGHT LINE S-S'
UNNAMED FAULT IV - MOTION AND POSITION MAPPED BY MAM
UNNAMED FAULT V - COINCIDES WITH INFLECTION POINT MAPPED BY MAM
UNNAMED FAULT VI - COINCIDES WITH INFLECTION POINT MAPPED BY MAM
UNNAMED FAULT VII - PROBABLY OBSCURED BY UNUSUAL GRADIENTS IN BASEMENT
UNNAMED FAULT VIII - MOTION AND POSITION MAPPED BY MAM
[ ] SMT CONDUCTIVE ANOMALIES
[ ] MODELED CONDUCTIVE HALFSPACE DERIVED FROM SMT
[ ] UNUSUAL MAGNETIC GRADIENTS MAPPED BY MAM

FIGURE 5

IDEALIZED CROSS SECTION C-C', DIXIE VALLEY, NEVADA
DATA DERIVED FROM SCALAR MAGNETOTELLURICS AND MULTILEVEL AEROMAGNETICS ALONG FLIGHT LINES C-C' AND C-C' EXTENSION

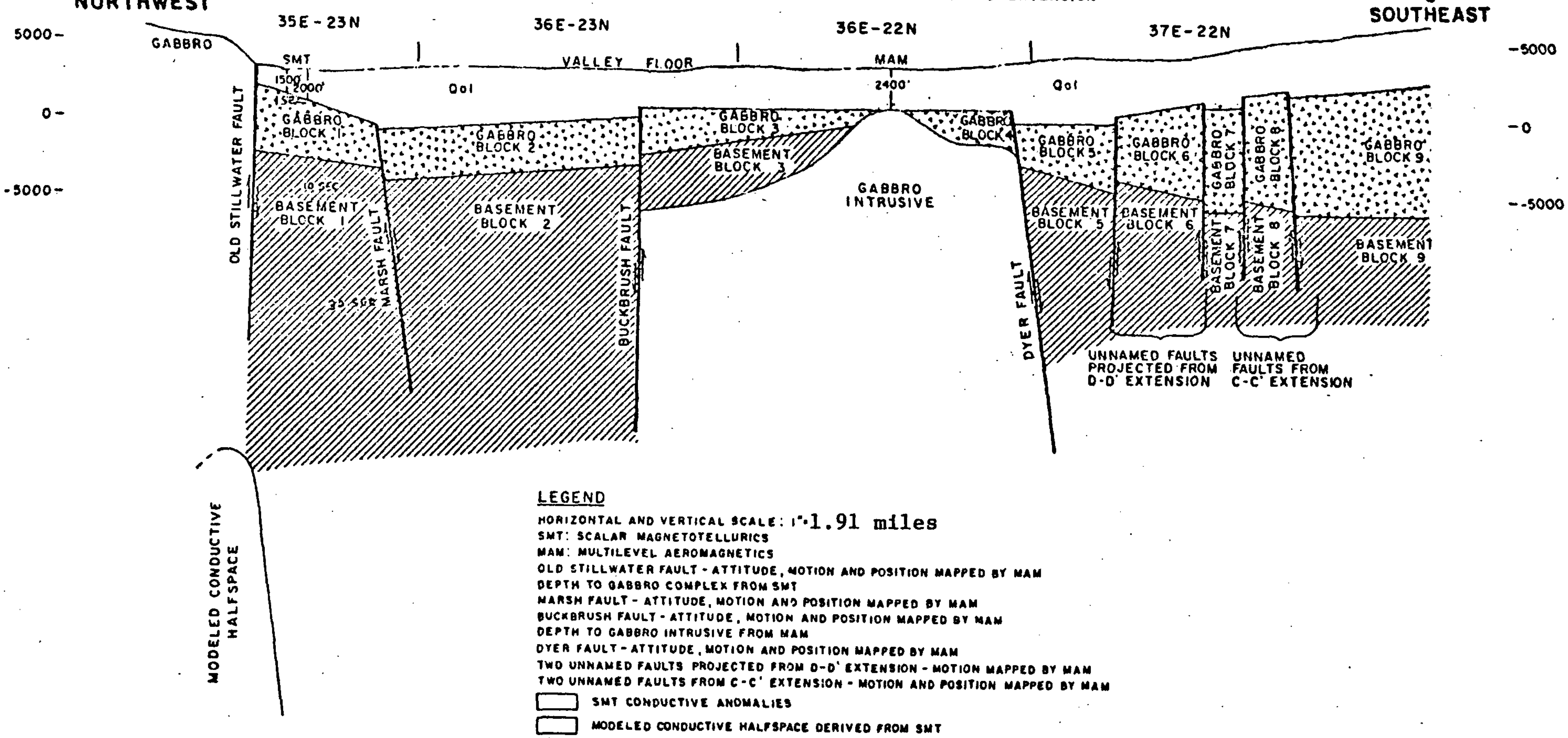


FIGURE 6

is a photograph of the western boundary of Dixie Valley and the Stillwater Range. Drilling locations are shown (Millican #H-1 and #H-2).

Reconnaissance Drilling and Temperature Logging Program

Based on the identification and confirmation of heat sources and overlying conductive areas, an intermediate-depth thermal-gradient drilling program was begun in early summer of 1978. To date, drilling data is available on four holes (see Plate II for locations), two on Millican Oil Company land and two on land held by Southland Royalty Company. A fifth hole is presently being drilled on Southland Royalty land.

Millican No. H-1 site was selected to evaluate the thermal gradient and stratigraphy above one of the anomalies produced by the MT survey ("Mine" anomaly). In addition, the site was also selected to evaluate the dip of the range-front fault and/or associated faults. Scouting information indicated that an intermediate depth hole had been drilled in the immediate vicinity which encountered down-hole temperatures greater than 125° C.

Millican No. H-1 encountered a recorded bottomhole temperature of 97.3° C at 1,500 feet (T. D.). Although a full lithologic log has not been completed to date, the supervising geologist (R. L. Jodry, Consultant for Southland Royalty) indicated that a gabbroic-like unit with an unusually high magnetite content was encountered at approximately 1,145 feet; a metasedimentary unit was encountered at 1,470 feet to total depth of well (1,500 feet).

FIGURE 7: PHOTOGRAPH LOOKING NORTHEAST TOWARD DRILLING SITES H-1 AND H-2. (SEE PLATE IV FOR COVERAGE OF PHOTOGRAPH).

During the drilling, ten-foot samples were taken for later study and evaluation. Down-hole temperature data are tabulated in Tables 1 and 2 (rerun). Figure 8 is a generalized temperature-depth plot with associated relative thermal gradient per 100 feet. Note increase in ΔT at top of grabbroic unit (between 1,100 and 1,200 feet depth).

Millican No. H-2 location was selected to evaluate the thermal gradients and stratigraphy above the major "Stillwater" MT anomaly. Low temperatures and a low thermal gradient were encountered to 1,500 feet T.D. Lithology consisted of alluvium, interbedded valley fill and lucustrine deposits. A gabbroic unit was not encountered. Table 3 shows recorded down-hole temperatures. Figure 9 is the temperature-gradient-depth plot.

Southland Royalty hole locations were also selected to evaluate either anomalous areas or fault zones. Temperatures and gradients were reportedly lower than Millican No. H-1.

Geothermetric Spring Sampling and Regional Data Collection

Two major hot springs on the boundary of the Humbolt Lopolith in Dixie Valley have been sampled over the past two years (see Figure 10). Short-term variations in geochemical character have been monitored. Short-term variations were discussed in a previous report by Keplinger and Associates, Inc. (September 16, 1977). The indicated variations were small.

Additional samples, however, were obtained during 1978 which indicate that substantial geochemical variations do occur over the long-term

TABLE 1: MILLICAN HOLE H-1 TEMPERATURE GRADIENT DATA. LOGGED MAY 16, 1978 (SECTION 16, T24N, R36E)

DEPTH	°C
0	22.65
40	38.70
80	47.50
120	52.80
160	57.00
200	58.70
240	59.7
280	60.4
320	61.6
360	62.5
400	63.6
440	64.9
480	66.3
520	67.6
560	68.8
600	69.8
640	70.8
680	71.6
720	73.6
760	74.1
800	74.8
840	75.5
880	76.5
920	77.5
960	78.6
1000	79.5
1040	80.2
1080	80.9
1100	81.6
1120	81.5
1140	81.9
1160	83.0
1180	83.7
1200	84.4
1220	84.8
1240	85.3
1260	85.9
1280	86.5
1300	87.2
1320	88.2
1340	88.8
1350	89.3
1360	89.6
1370	89.9
1380	90.1
1390	90.4
1400	90.8
1410	91.3
1420	91.9
1430	92.3
1440	92.7
1450	93.1
1460	93.7
1470	94.3
1480	95.0
1490	95.7
1500	96.4

TABLE 2: MILLICAN HOLE H-1 TEMPERATURE GRADIENT DATA LOGGED JUNE 7, 1978 (SECTION 16, T24N, R36E)

DEPTH	°C	DEPTH	°C	DEPTH	°C
0	37.3	600	72.2	1200	88.1
10	22.3	10	72.5	10	88.4
20	27.7	20	72.8	20	88.6
30	32.1	30	73.1	30	88.9
40	34.7	40	73.3	40	89.2
50	37.9	50	73.5	50	89.5
60	41.8	60	73.7	60	89.8
70	44.7	70	73.9	70	90.1
80	46.1	80	74.1	80	90.4
90	47.4	90	74.4	90	90.7
100	48.7	700	74.7	1300	91.0
10	50.2	10	75.0	10	91.4
20	51.8	20	75.2	20	91.7
30	53.4	30	75.4	30	92.0
40	54.8	40	75.7	40	92.3
50	56.1	50	76.0	50	92.6
60	57.1	60	76.2	60	92.9
70	57.9	70	76.4	70	93.2
80	58.7	80	76.7	80	93.5
90	59.2	90	76.9	90	93.8
200	59.6	800	77.2	1400	94.2
10	59.8	10	77.5	10	94.5
20	59.9	20	77.8	20	94.8
30	60.1	30	78.0	30	95.1
40	60.4	40	78.2	40	95.4
50	60.7	50	78.5	50	95.7
60	61.0	60	78.8	60	96.0
70	61.3	70	79.0	70	96.4
80	61.6	80	79.3	80	96.7
90	61.8	90	79.5	90	97.0
300	62.1	900	79.8	1500	97.3
10	62.4	10	80.1		
20	62.7	20	80.4		
30	63.0	30	80.8		
40	63.3	40	81.1		
50	63.6	50	81.4		
60	63.9	60	81.6		
70	64.2	70	81.9		
80	64.5	80	82.1		
90	64.8	90	82.3		
400	65.3	1000	82.5		
10	65.8	10	82.7		
20	66.2	20	83.0		
30	66.6	30	83.3		
40	67.0	40	83.6		
50	67.3	50	83.9		
60	67.7	60	84.1		
70	68.1	70	84.4		
80	68.5	80	84.6		
90	68.8	90	84.9		
500	69.2	1100	85.1		
10	69.4	10	85.3		
20	69.8	20	85.5		
30	70.1	30	85.9		
40	70.4	40	86.3		
50	70.7	50	86.6		
60	71.0	60	86.9		
70	71.3	70	87.2		
80	71.6	80	87.5		
90	71.9	90	87.8		

TABLE 3: MILLICAN HOLE H-2 TEMPERATURE GRADIENT DATA, LOGGED JUNE 21, 1978 (SECTION 31, T24N, R36E)

DEPTH	°C	DEPTH	°C
0	17.0	800	36.2
20	19.0	20	36.6
40	19.5	40	37.0
60	20.3	60	37.5
80	21.0	80	37.9
100	21.2	900	38.5
20	21.6	20	38.9
40	21.9	40	39.3
60	22.3	60	39.7
80	22.9	80	40.1
200	23.3	1000	40.6
20	24.2	20	41.0
40	24.5	40	41.4
60	25.0	60	41.8
80	25.4	80	42.2
300	25.8	1100	42.7
20	26.2	20	43.1
40	26.7	40	43.5
60	27.1	60	43.9
80	27.5	80	44.3
400	27.9	1200	44.7
20	28.3	20	45.1
40	28.7	40	45.5
60	29.0	60	46.0
80	29.4	80	46.4
500	29.7	1300	46.8
20	30.2	20	47.2
40	30.6	40	47.7
60	31.0	60	48.1
80	31.4	50	48.6
600	31.9	1400	49.0
20	32.3	20	49.4
40	32.7	40	49.8
60	33.1	60	50.2
80	33.6	80	50.7
700	34.0	1500	51.2
20	34.4		
40	34.9		
60	35.3		
80	35.7		

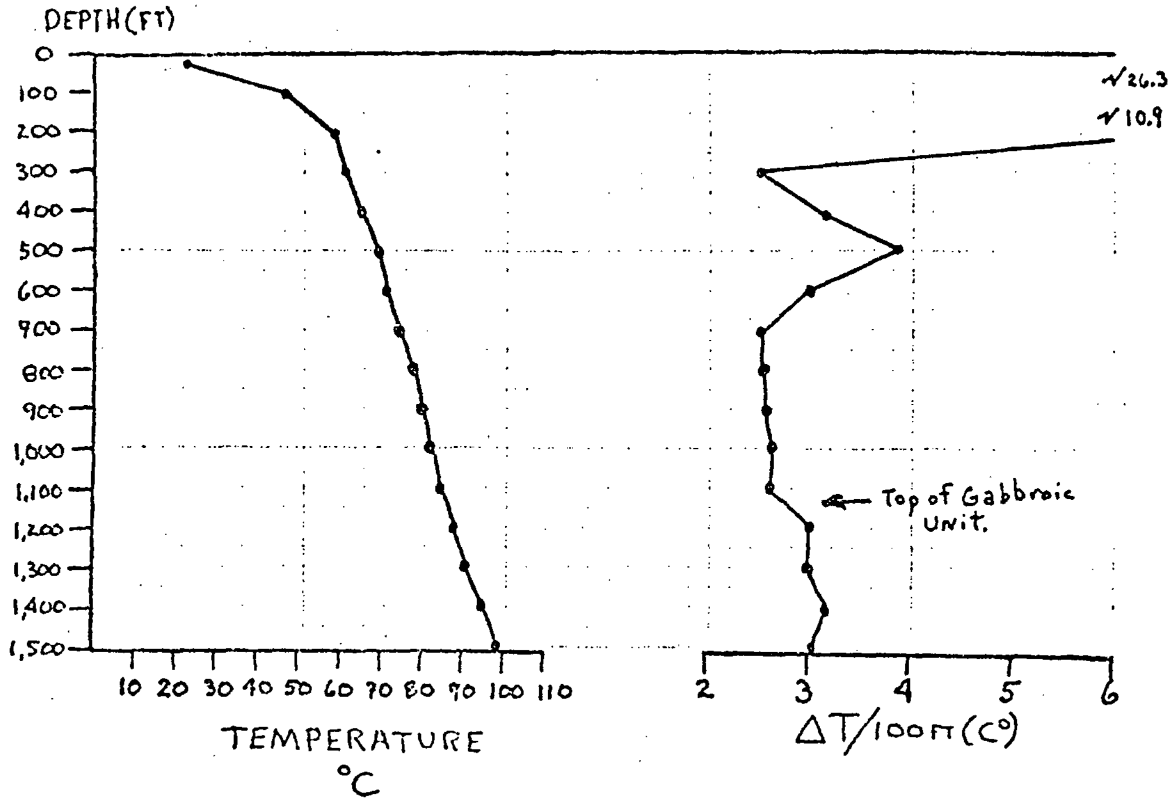


FIGURE 8: Millican Oil #H-1 Temperature - Depth Plot with Relative Thermal Gradient Per 100 ft.

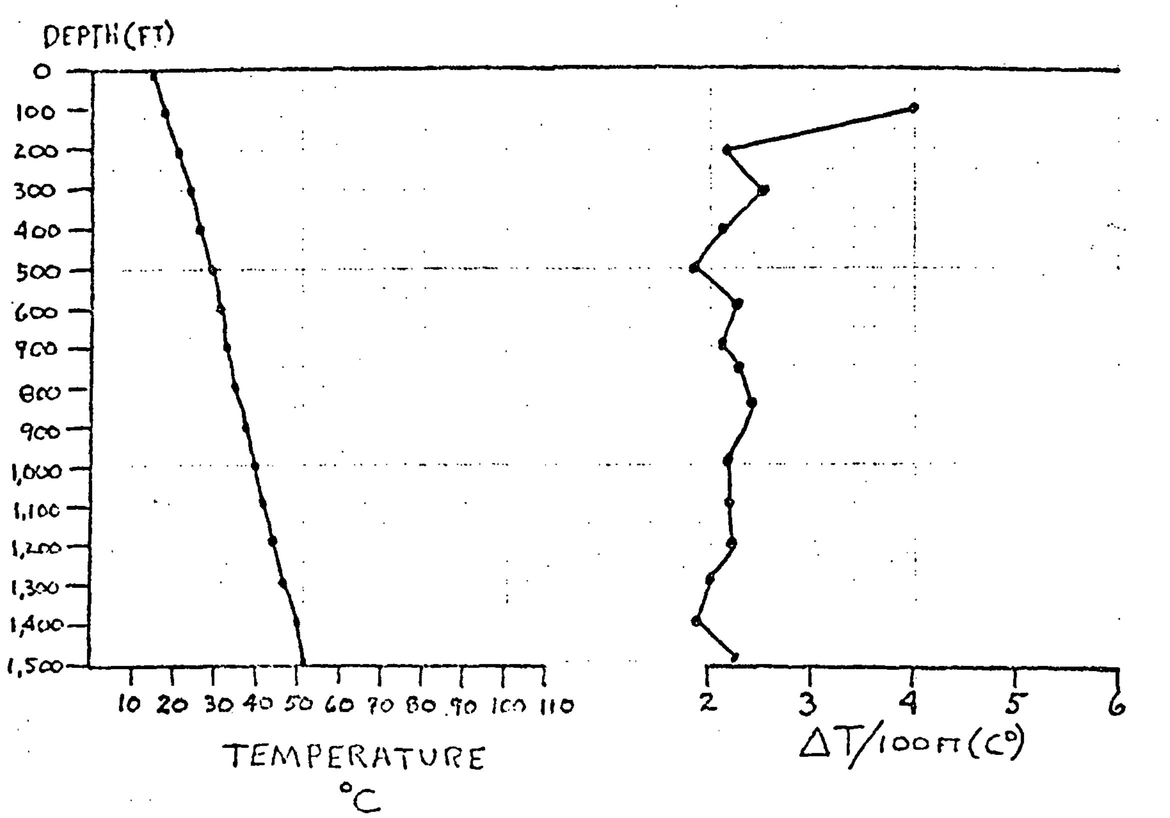


FIGURE 9: Millican Oil #H-2 Temperature - Depth Plot with Relative Thermal Gradient Per 100 ft.

KEPLINGER and Associates, inc.

FIGURE 10: PHOTOGRAPH LOOKING EASTWARD ACROSS DIXIE VALLEY FROM SPRING NUMBER 2 SITE. NOTE NUMEROUS FUMING SPRING OUTLETS. (SEE PLATE IV FOR COVERAGE OF PHOTOGRAPH.

(seasonal?), in this case one year (see Table 4). Although data obtained to date do not permit a firm conclusion because of limited baseline information, it is apparent that the springs are in direct communication with seasonal surface recharge from the Stillwater Range, which supports previous tentative conclusions that mixing of meteoric ground water with deep, heated reservoir ground water does occur. This will act to depress the calculated geothermetric temperature of the deep reservoir. If spring geochemistry were found to be constant, however, mixing would not be indicated and any calculated temperature would be indicative of subsurface conditions, within the limits imposed by the methods used.

To assess the general similarity of Dixie Valley spring geochemistry with other areas of known geothermal significance, a comparison of spring geochemistry of Dixie Valley, Beowawe and Brady Hot Spring is shown on Table 5. Beowawe KGRA is located approximately 55 miles to the northeast of Dixie Valley, while Brady Hot Spring (Brady - Hazen KGRA) is located approximately 40 miles to the southwest (see Figure 11). These areas are presently undergoing extensive exploration. Economic consideration of these areas will be discussed later in this report. Table 6 is a general summary of KGRA characteristics and recent activity within a 125 mile radius of Dixie Valley.

It is apparent in Table 5 that Dixie Valley spring geochemistry is not significantly different from that of other springs in areas under intensive exploration by industry. The extent to which mixing is involved in the other springs is presently unknown.

TABLE 4

VARIATIONS IN DIXIE VALLEY SPRING GEOCHEMISTRY

(PPM)

Sampling Period	#Samples**		Li	Na	K	Mg	Ca	HCO_3	Cl	SO_4	SiO_2	Temperature(^oC)***
1977*	8	$\bar{m}$	0.64	194.	8.08	0.35	8.04	106.4	216.	57.	142.3	67.6
		St.Dev.	0.004	8	0.4	0.1	0.7	22.	67.	3.	1.8	0.6
1978*	4	$\bar{m}$	0.40	237	6.1	0.01	-	88.0	235.0	114.	117.0	57.5
		St.Dev.	0.005	57	0.4	0.008	-	9.2	5.8	28.	0.8	2.9

* Samples taken: *June 29 through July 7, 1977 and *April 28 and May 4, 1978

** Samples taken at Spring #2

*** Ambient Temperature mean during 1977 sampling period: 26.4; 1978 period: 18.3

TABLE 5
COMPARISON OF HOT SPRING
GEOCHEMISTRY OF DIXIE VALLEY,
BEOWAWE AND BRADY HOT SPRING KGRAs. (See Figure 11)

(PPM)

KGRA Location	#Samples		Li	Na	K	Mg	Ca	HCO_3	Cl	SO_4	B	CO_2	SiO_2	pH	Temp.(°C)	Adj. **** TDS
Dixie Valley																
Spring #1	8	$\bar{m}$	0.88	478.	14.7	0.75	65.05	58.	704.	83.	-	-	86.	7.6[illegible]	57.[illegible]***	1,4[illegible]
		Std.Dev.	0.01	24.	0.2	0.06	0.4	7.	97.	6.	-	-	4.	0.09	0.09	
Spring #2	12		0.56	208.	7.4	0.24	8.04*	100.	222.	76.	1.1**	4.0**	134.	8.33	65.7***	763
		Std.Dev.	0.12	37.	1.1	0.19	0.65	20.	54.	32.	0.4	1.97	13.	0.31	4.1	
Beowawe	9	$\bar{m}$	1.38	236.	24.1	0.53	0.84	123.*	48.	95.	1.6	-	358.	9.5*	94.3	889
		Std.Dev.	0.21	9.	5.9	0.58	0.36	55.	11.	15.	0.7	-	148.	0.3	3.9	
Brady Hot Springs	3	$\bar{m}$	1.1	570	52.7	1.3	40.0	144.	644.	344.	4.6	-	192.	7.3	46.0	1,394
		Std.Dev.	0.8	321.	18.8	1.3	15.9	70.	521.	31.	7.2	-	73.	0.2	2.7	

$\bar{m}$ - Mean

* - 8 Samples

** - 4 Samples

*** - 16 Samples

**** - For comparison purposes, major anions and cations shown have been summed.

TABLE 6
General Summary of KGRA Characteristics and Activity (See Figure #1)

KGRA Area	Surface Temperature	Subsurface Temperature	Geochemical SiO2	Geochemical NA-K-Ca	Estimated Depth to Top of Reservoir	Area of Reservoir (Acres)	Recent Activity: Companies	Recent Activity: Maximum Drilling Depth	Recent Activity: Maximum Temperature
Beowawe	98°	240°	226°	242°	3,300'	5,200	Magma Power (Chevron)	9,600'	
							Stand. Calif.	700'	214°
							Phillips		
Brady Hot Springs	98°	214°	179°	-	1,600'	3,000	Magma Power	4,500'	
							Earth Energy	5,000'	
							Phillips Union	7,000'	
							Stand. Calif.	5,000'	214°
Desert Peak	-	-	-	-	-	-	Phillips	7,000'	250°
Rye Patch	-	-	-	-	-	-		3,200'	200°
Leach	96°	170°	155°	176°	-	-	Phillips	1,850'	200°
Steam Boat Springs	96°	210°	207°	226°	1,000'	1,500	Phillips		
							-	725'	185°
							Magma Power	-	-
							Southern Union	-	-
Dixie Valley	82°	>200°	175°*	146°*	3,000'	32,000(?)	Millican, Southland Royalty, Sunoco Republic Geothermal	1,500'	97°

*Mixing indicated.

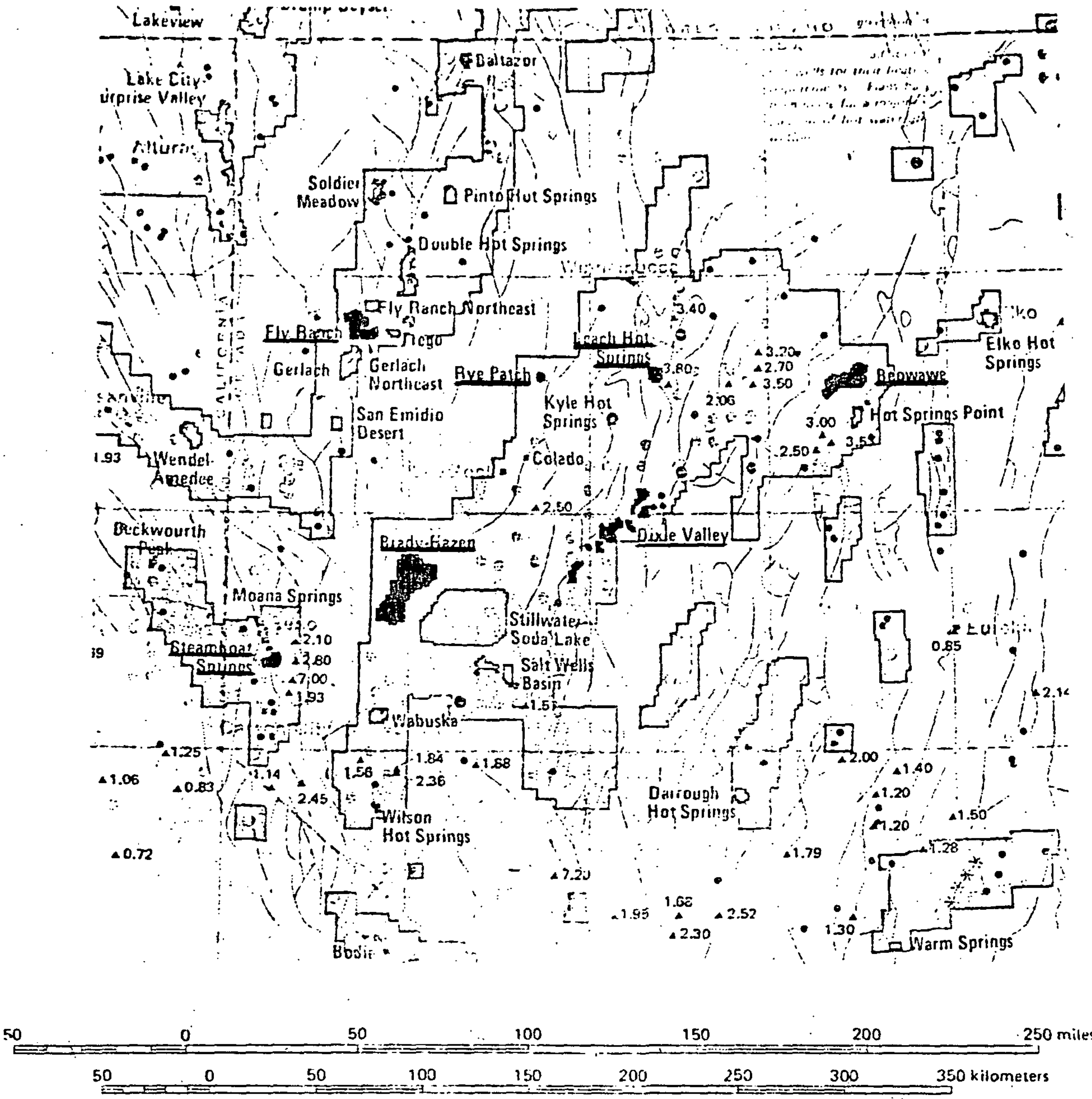


FIGURE 11: LOCATION MAP FOR DIXIE VALLEY AND NEARBY KGRA'S

It should be noted that local geology will have a dramatic effect on reservoir ground water. If carbonate units are present in the reservoir, the possibility exists that serious calcium and alkalinity levels could be present which could promote sealing within the reservoir and scaling within production wells and collection pipes. Monitoring of springs should continue to evaluate geochemical variations in Dixie Valley.

III. LAND ACQUISITIONS

Over the past 4 years, leasing of federal lands on either a competitive basis (lease bid) or noncompetitive basis has increased significantly in Nevada. Table 7 is a summary of the competitive bidding held during 1976 on lands in Dixie Valley. In 1977, Millican Oil bid on prime land in Dixie Valley (see Table 8). Non-competitive federal leases were obtained in 1975, 1976 and 1978. Regional bidding activity is shown in Table 9. Lease costs, of course, depend upon the interest shown by industry. Lands requiring competitive bid sales are within known Geothermal Resource Areas (KRGA's), areas previously defined by the U. S. Geological Survey as having significant geothermal potential.

As of late 1977, Millican Oil held or controlled by agreement 33,920 federal acres in Dixie Valley. At present Millican holds (or controls) approximately 54,400 federal acres, of which 9,600 acres is 50% of land held jointly with Southland Royalty (See Plate IV).

Southland Royalty has increased its land holdings from 14,080 (in late 1977) to 27,520 federal acres, which also includes 9,600 acres of the Millican Oil-Southland Royalty joint venture.

TABLE 7

BIDDING HISTORY OF THE COMPETITIVE GEOTHERMAL
LEASE SALES ON FEDERAL LAND

4/20/76 NEVADA DIXIE VALLEY KGRA

OFFERED: 34911.07 ACRES, 16 TRACTS,

RECEIVED BIDS: 14793.59 ACRES, 7 TRACTS, 10 BIDS, TOTAL BIDS = $ 204869.58, TOTAL HIGH BIDS = $ 160840.40

ACCEPTED BIDS: 14793.59 ACRES, 7 TRACTS, HIGH BIDS = $ 160840.40

TRACT 4, 2560.00 ACRES, 0 BIDS, NO BID !

TRACT 5, 2319.58 ACRES, 0 BIDS, NO BID !

TRACT 6, 2518.36 ACRES, 0 BIDS, NO BID !

TRACT 7, 1920.00 ACRES, 1 BIDS, LEASED ! REPUBLIC GEOTHERMAL, HIGH BID, LEASE N-12859
$ 13814.98 $ 7.20/ACRE, REPUBLIC GEOTHERMAL

TRACT 8, 1920.00 ACRES, 1 BIDS, LEASED ! REPUBLIC GEOTHERMAL, HIGH BID, LEASE N-12860
$ 12466.80 $ 6.49/ACRE, REPUBLIC GEOTHERMAL

TRACT 9, 2242.50 ACRES, 1 BIDS, LEASED ! REPUBLIC GEOTHERMAL, HIGH BID, LEASE N-12861
$ 7465.86 $ 3.33/ACRE, REPUBLIC GEOTHERMAL

TRACT 10, 1905.50 ACRES, 3 BIDS, LEASED ! SUNOCO ENERGY DEVELOPMENT CO., HIGH BID, LEASE N-12862
$ 35994.90 $ 18.89/ACRE, SUNOCO ENERGY DEVELOPMENT COMPANY
$ 13731.04 $ 7.21/ACRE, REPUBLIC GEOTHERMAL
$ 13662.44 $ 7.17/ACRE, CHEVRON OIL COMPANY

TRACT 11, 2308.59 ACRES, 2 BIDS, LEASED ! SUNOCO ENERGY DEVELOPMENT CO., HIGH BID, LEASE N-12863
$ 66695.17 $ 28.89/ACRE, SUNOCO ENERGY DEVELOPMENT COMPANY
$ 16635.70 $ 7.21/ACRE, REPUBLIC GEOTHERMAL

TRACT 12, 2542.92 ACRES, 0 BIDS, NO BID !

TRACT 13, 2560.00 ACRES, 1 BIDS, LEASED ! SUNOCO ENERGY DEVELOPMENT CO., HIGH BID, LEASE N-12864
$ 20198.40 $ 7.89/ACRE, SUNOCO ENERGY DEVELOPMENT COMPANY

TRACT 14, 2560.00 ACRES, 0 BIDS, NO BID !

TRACT 15, 1263.23 ACRES, 0 BIDS, NO BID !

TRACT 16, 1891.56 ACRES, 0 BIDS, NO BID !

TRACT 17, 2492.64 ACRES, 0 BIDS, NO BID !

TRACT 18, 1970.00 ACRES, 0 BIDS, NO BID !

TRACT 19, 1937.00 ACRES, 1 BIDS, LEASED ! AL-AQUITAINE EXPLORATION LIMITED, HIGH BID, LEASE N-12865
$ 4203.29 $ 2.17/ACRE, AL-AQUITAINE EXPLORATION LIMITED

TABLE 8

BIDS AND RESULTS OF GEOTHERMAL LEASE SALE

JULY 19, 1977

STATE OF NEVADA

BLM Geothermal Lease Sale - N-16930 - July 19, 1977:

Leasing Unit No. 1:	Total	Per Acre
Earth Power Corp.	$8,811.40	$3.77
Leasing Unit No. 2:		
Earth Power Corp.	$7,385.60	$5.77
Leasing Unit No. 3:		
Earth Power Corp.	$5,318.40	$2.77
Leasing Unit No. 4:		
Republic Geothermal, Inc.	$13,519.36	$5.281
Leasing Unit No. 5:		
Republic Geothermal, Inc.	$16,961.52	$7.312
Leasing Unit No. 6:	No Bids	
Leasing Unit No. 7:		
Sunoco Energy Development Co.	$48,358.40	$18.89
Millican Oil Company	$82,099.20	$32.07
Amax Exploration, Inc.	$28,800.00	$11.25
Republic Geothermal, Inc.	$104,128.25	$40.675
Leasing Unit No. 8:		
Millican Oil Company	$55,122.25	$22.07
Sunoco Energy Development Co.	$35,321.16	$13.89
Amax Exploration, Inc.	$28,608.75	$11.25
Republic Geothermal, Inc.	$49,214.86	$19.354
Southland Royalty Company	$51,544.99	$20.27
Leasing Unit No. 9:		
Millican Oil Company	$18,099.20	$7.07
Leasing Unit No. 10:		
Millican Oil Company	$3,878.12	$3.07
Leasing Unit No. 11:		
Millican Oil Company	$5,807.09	$3.07
Leasing Unit No. 12:	No Bids	
Leasing Unit No. 13:	No Bids	

TABLE 9: COMPETITIVE BIDDING, DIXIE VALLEY AND OTHER AREAS, 1976

STATE KGRA	Unit No.	Date of Lease Sale	Acreage	No. of Bids	Range of Bidding	High Bidder	Lessee	$/Acre
San Emidio Desert	15	1-20-76 6-15-76	1,699	0		Reoffered as tract 26		
	16	1-02-76	1,612	1	16,720.00	Chevron Oil Company	Chevron Oil Co.	10.37
	17	1-20-76 6-15-76	1,920	0		Reoffered as tract 27		
Sub-total		1-20-75 6-15-76	5,231 3,619	1 0	Total of Accepted Bids $ 16,720.00 0			
Wilson Hot Springs	19	3-03-75	1,294	1	4,775.00	Chevron Oil Company	Chevron Oil Co.	3.69
Darrough Hot Springs	1	4-20-76	1,983	0				
	2	4-20-76	2,260	0				
	3	4-20-76	1,560	0				
Sub-total			5,803	0	Total of Accepted Bids $0			
Dixie Valley	4	4-20-76	2,560	0				
	5	4-20-76	2,320	0				
	9	4-20-76	2,243	1	7,466.86	Republic Geothermal	Republic Geothermal	3.33
	10	4-20-76	1,906	3	13,662.44 - $ 35,994.90	Sunoco Energy Development	Sunoco Energy Dev.	18.88
	11	4-20-76	2,309	2	16,635.70 - 66,695.17	Sunoco Energy Development	Sunoco Energy Dev.	28.88
	12	4-20-76	2,543	0				
	13	4-20-76	2,560	1	20,198.40	Sunoco Energy Development	Sunoco Energy Dev.	7.89
	14	4-20-76	2,560	0				
	15	4-20-75	1,263	0				
	16	4-20-76	1,892	0				
	17	4-20-76	2,493	0				
	18	4-20-76	1,970	0				
	19	4-20-76	1,937	0				
Sub-total			34,911	10	Total of Accepted Bids $ 160,840.40			
Silver Peak	20	4-20-76	2,547	1	$ 13,471.35	Magma Power Company	Magma Power Co.	5.29
	21	4-20-76	2,378	0				
Sub-total			4,924	1	Total of Accepted Bids $ 13,471.35			
Monte Neva	1	8-18-76	1,946	0				
	2	8-18-76	1,959	0				
	3	8-18-76	1,360	0				
	4	8-18-75	2,282	0				
Sub-total			7,547	0	Total of Accepted Bids $0			
Colado	1	8-18-76	640	0				
	6	10-19-76	640	1	$ 5,107.20	Getty Oil Company	Getty Oil Co.	7.98
sub-total			1,280	1	Total of Accepted Bids $ 5,107.20			
Ruby Valley	6	8-18-76	2,419	4	16,522.00 - $ 244,983.22	Union Oil Company	Union Oil Company	101.00
	7	8-18-75	640	0				
Sub-total			3,059	4	Total of Accepted Bids $ 244,988.22			
Rye Patch	8	8-18-76	801	2	15,002.73 - $ 32,360.74	Union Oil Company	Union Oil Co.	46.40
Leach Hot Springs	1	10-19-76	2,520	1	$ 4,435.20	Amin Oil USA, Inc.	Amin Oil USA	1.76
	2	10-19-76	2,482	1	4,369.06	Amin Oil USA, Inc.	Amin Oil USA	1.76
	3	10-19-76	2,609	1	4,591.84	Amin Oil USA, Inc.	Amin Oil USA	1.76

TABLE 9A: REGIONAL COMPETITIVE BIDDING, NEVADA, 1974-76

STATE KGRA	Unit No.	Date of Lease Sale	Acre-age	No. of Bids	Range of Bidding	High Bidder	Lessee	$/Acre
Brady-Hazen								
	19	6-15-76	2,536	0				
	20	6-15-76	1,505	1	7,917.62	Union Oil Co.	Union Oil Co.	5.26
Sub-total			42,497	6	$ 67,529.15			
Beowawe	1	12-18-74	1,943	2	$ 2,002.00 - $ 15,074.89	Chevron Oil Company	Chevron Oil Co.	7.75
	2	12-18-74	1,920	0				
	3	12-18-74	1,938	0				
	4	12-18-74	2,479	3	13,112.00 - 505,088.77	Chevron Oil Company	Chevron Oil Co.	203.00
	5	12-18-74	2,521	3	25,256.61 - 45,371.16	Getty Oil Company	Getty Oil Co.	18.00
	6	12-18-74	2,468	3	37,017.45 - 75,490.92	Chevron Oil Company	Chevron Oil Company	30.58
	7	12-18-74	844	0				
	8	12-18-74	2,419	1	30,231.63	Getty Oil Company	Getty Oil Company	12.50
Sub-total			14,113	12	*Total of Accepted Bids* $ 671,257.37			
Beowawe	21	6-15-76	1,920	0				
	22	6-15-76	1,938	1	$ 25,015.46	So. Union Production Co.	So. Union Prod. Co.	12.90
	23	6-15-76	844	0				
Sub-total			4,702	1	*Total of Accepted Bids* $ 25,015.46			
Hot Springs Point	1	12-18-74	640	0				
	2	12-18-74	2,141	2	$ 12,846.36 - $ 115,274.67	Chevron Oil Company	Chevron Oil Co.	53.84
	3	12-18-74	2,560	2	23,040.00 - 125,619.20	Chevron Oil Company	Chevron Oil Co.	49.07
Sub-total			5,341	4	*Total of Accepted Bids* $ 240,893.87			
Hot Springs Point	3	3-01-75	640			TRANSFER TO	Geo. Resources Intl.	
	3	7-03-75	640			Reoffered as tract 25		
	3	2-01-76	640			TRANSFER TO	Diablo Exploration	
	3	3-01-76	640			TRANSFER TO	Diablo Exploration	
	24	6-15-76	640	0				
	25	6-15-76	640	0				
Sub-total			1,280	0	*Total of Accepted Bids* $0			
Fly Ranch	1	4-08-75 9-23-75 1-20-76	1,801	0				
	2	4-08-75 1-20-76	2,037	0				
	3	4-08-75 7-01-75	1,467	2	3,007.47 - $ 7,702.07	Natomas Company Transfer	Natomas Company Thermal Power Co.	5.25
	4	4-08-75	2,161	1	16,790.97	Sun Oil Company	Sun Oil Company	7.77
	5	4-08-75	2,578	1	8,455.84	Calvert Drilling Company	Calvert Drilling Co.	3.28
	6	4-08-75	1,890	0		Reofferod as tract 3		
	7	4-08-75	2,545	1	8,348.88	Calvert Drilling Company	Calvert Drilling Co.	3.28
Sub-total		4-08-75 9-23-75 1-20-76	14,479 5,728 5,728	5 0 0	*Total of Accepted Bids* $ 41,297.76 0 0			
Stillwater Soda Lake	1	6-26-75 3-03-76	2,560	0		Reoffered as tract 2		
	2	6-26-75 3-03-76	2,609	0		Reoffered as tract 3		
	3	6-26-75 3-03-76	1,968	0		Reoffered as tract 4		
	4	6-26-75	2,528	1	$ 12,058.56	Phillips Petroleum Co.	Phillips Pet. Co.	4.77

Other holdings within Dixie Valley are shown on Plate IV.

IV. U.S. DEPARTMENT OF ENERGY PROGRAMS

A request for proposal was received from the U.S. Department of Energy regarding a DOE project involving a geothermal reservoir assessment case study of the northern Basin and Range Province. A proposal was submitted as a cooperative venture between Millican Oil Company, Southland Royalty Company and the Minerals Research Institute of the Mackay School of Mines, University of Nevada at Reno. Integration of industrial and academic expertise is provided in the proposed venture.

The proposal is presented in a multi-phase format, with each phase encompassing specific tasks. This format inherently includes major decision-points, both within each phase and between phases, to allow for redesign or modification of each of the following tasks or phases based upon evaluation of previous results. In addition, it provides DOE with the option of selecting the proposal as an entire program leading to reservoir assessment, or as a multi-phase program in which each phase can be sequentially selected and negotiated.

The contractural posture which is proposed will have the Southland-Millican cooperative venture as Prime Contractor, with the University of Nevada group as a sub-contractor. All phases of task accomplishment and reporting will be achieved with the cooperative assistance of University personnel coordinated through the Prime Contractor's representatives.

This proposal contains provisions for the sale of: 1) existing data derived from surface and subsurface investigations, and 2) development of new data from subsurface investigations and from the drilling of a minimum of three deep exploratory wells.

The industrial-academic effort will involve subprojects on 1) the hydrogeologic framework to assess recharge and potential reservoir characteristics, 2) the structural and tectonic setting in the Stillwater Range-Dixie Valley-Clan Alpine area to evaluate all aeromagnetic and other data for developing a structural model of the basin, 3) the alteration effects within basin rocks to petrologically evaluate rock behavior in the geothermal environment (relative to sealing and faulting) and 4) the seismic framework via microseismicity to support development of a technically appropriate structural model of the Dixie Valley area.

The proposal is designed to have the first well under way by early 1979, with the first drilling site to be selected from eleven permitted sites already approved by the U.S. Bureau of Land Management. The final selection of the first well location will be made following review of the existing data by the industrial-academic personnel involved in the venture. The second well site is to be based on data developed from new surface investigations and the results of the first well. The third well site is to be selected based upon a final model of the area which will be developed by integrating all data from surface and subsurface investigations completed by the time the rig is ready to move off the second well. It is expected that the entire program, including well testing and reservoir analysis, will be completed by the end of FY 1980.

The proposal was presented on a fixed-cost basis with inflation adjustment for four phases of work. The proposal is flexible with regard to method of cost-sharing, but has incorporated fixed price (with inflation adjustment) in the proposal because of its relative ease of administration.

A highly significant aspect of this proposal is the large geographical area involved in the Millican-Southland acreage. A substantial amount of existing data is available for immediate dissemination which indicates the existence of a significant potential geothermal reservoir. Further, the exploratory drilling program will result in a near-term assessment of not only the Dixie Valley area, but of the state-of-the art techniques utilized in evaluating geothermal prospects.

The Millican Oil-Southland Royalty cooperative venture was recently advised by DOE that the proposal has been approved on the basis of technical feasibility. Final contract negotiations are to begin in the near future.

V. GEOTHERMAL DEVELOPMENT AND ECONOMICS

Geothermal exploration has increased in Nevada over the past few years. U.S. Department of Energy has recently estimated that Nevada will rank second only to California in growth of installed geothermal electric capacity by 1983 (see Figure 12). Two 50 MWe plants may be in operation by 1983 (see Table 10). Brady Hot Springs and Beowawe are presently under intensive evaluation (see Figure 11). DOE's development scenario for Brady Hot Springs, Beowawe, Steamboat Springs (Nevada) and Leach KGRA's are included in the Appendix. It is apparent that strong similarities exist between Brady Hot Springs and Beowawe and Dixie Valley, the former areas being at an advanced exploration stage relative to Dixie Valley at this time. However, input derived from the proposed DOE research and development (including drilling) will close the gap in defining reservoir potential (temperature and flow rate) within 2 years, while the other areas continue to lead the way in field development and production techniques.

The power on-line schedule for the Nevada sites shown in Table 11 suggests the necessary well construction schedule that allows for a sufficient number of exploration, production, reinjection and replacement wells to meet the specified power production goal. Although not as advanced in exploration as Brady Hot Springs or Beowawe, Dixie Valley has similar characteristics and potential. Conservative estimates of a possible schedule can now be made to define the reservoir requirements before deep drilling is begun. Temperature and flow-rate minimums can now be established (based on nearby areas) that will guide future economic considerations of Dixie Valley. This is a fortunate situation in many respects because the reliability of future economic considerations will be higher in Dixie Valley (if similar temperatures and flow-rates can be produced) than early economic studies conducted on the Brady Hot Springs and Beowawe areas.

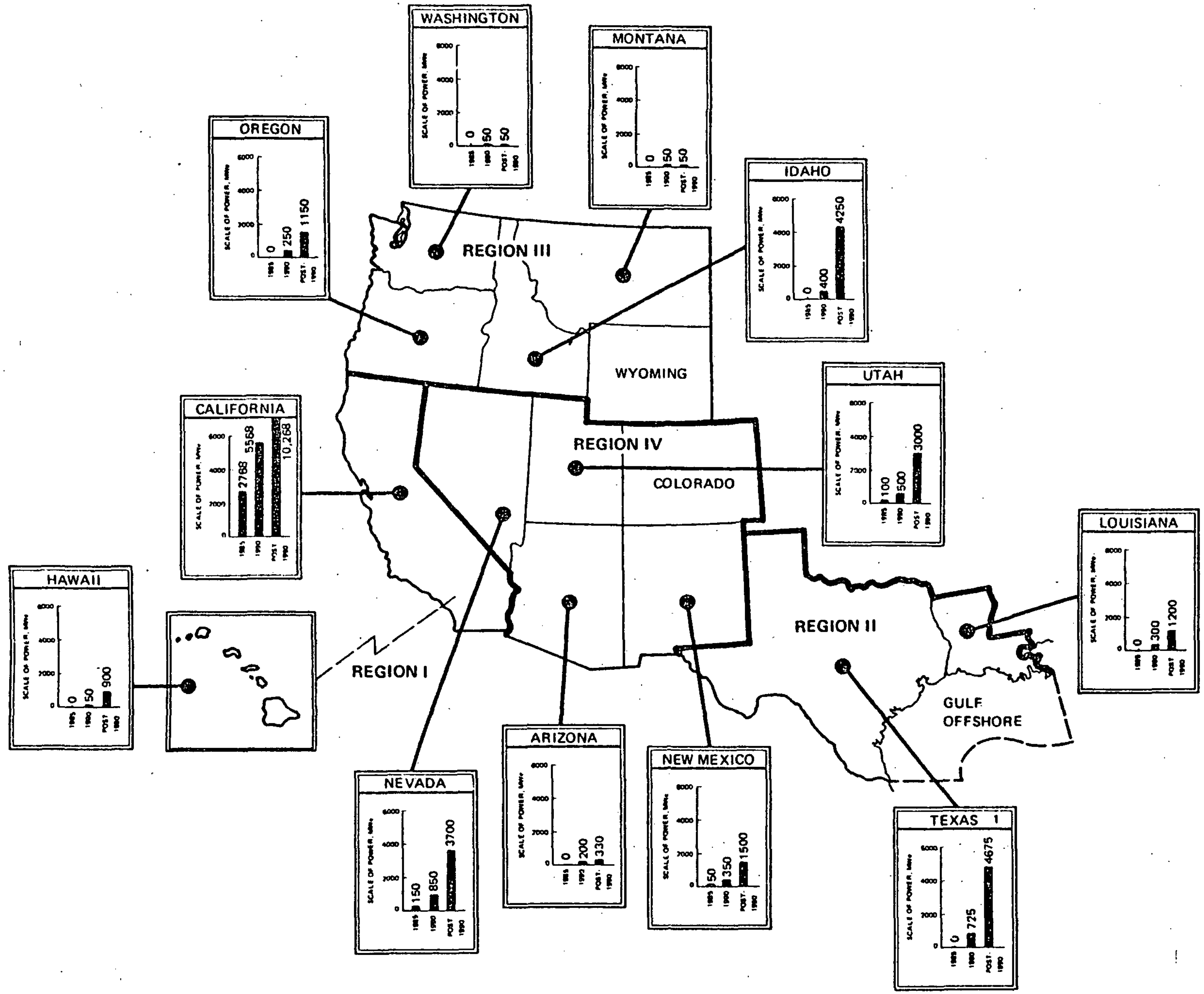


FIGURE 12: POSTULATED GROWTH OF INSTALLED GEOTHERMAL ELECTRIC CAPACITY [1]No credit for methane included.

TABLE 10

GEOTHERMAL DEVELOPMENT SCENARIOS FORMULATED BY THE DIVISION OF GEOTHERMAL ENERGY[1]

PROSPECT	GENERATING CAPACITY INSTALLED EACH YEAR (MW_e)										
	Pre-1983	1983	1984	1985	1986	1987	1988	1989	1990	Post 1990	TOTAL
CALIFORNIA & HAWAII											
Brawley, CA	–	50	–	50	–	100	100	100	100	500	1,000
Coso Hot Springs, CA	–	–	–	50	50	50	150	150	150	–	600
East Mesa, CA	–	–	–	50	–	–	50	–	–	–	100
Geysers, CA (liquid-dominated)	–	–	–	100	100	100	100	100	100	400	1,000
Geysers, CA (steam)	1678	160	220	110	–	–	–	–	–	–	2,168
Glass Mt., CA	–	–	–	–	–	–	–	–	50	–	50
Heber, CA	–	50	–	50	–	100	100	–	–	700	1,000
Lassen, CA	–	–	–	–	–	50	–	–	50	–	100
Mono-Long Valley, CA	–	–	–	50	–	100	–	–	100	–	250
Puna, HI	–	–	–	–	–	–	–	–	50	850	900
Salton Sea, CA	–	50	–	100	75	75	100	100	100	1400	2,000
Surprise Valley, CA	–	–	–	–	50	–	50	100	100	1700	2,000
NORTHWEST											
Alvord, OR	–	–	–	–	–	50	–	–	50	200	300
Baker Hot Springs, WA	–	–	–	–	–	–	–	–	50[2]	–	–
Bruneau-Grandview, ID	–	–	–	–	–	50	–	–	100	3000	3,150
Mount Hood, OR	–	–	–	–	–	–	–	–	50[2]	–	–
Raft River, ID	–	–	–	–	–	–	50	–	50	–	100
Vale Hot Springs, OR	–	–	–	–	–	–	50	–	50	700	800
Weiser-Crane Creek, ID	–	–	–	–	–	–	50	–	100	850	1,000
West Yellowstone, MT	–	–	–	–	–	–	–	–	50[2]	–	–
SOUTHWEST											
Brady Hot Springs, NV	–	50	–	–	50	–	100	–	100	700	1,000
Beowawe, NV	–	50	–	–	50	–	50	–	100	750	1,000
Chandler, AZ	–	–	–	–	50	–	–	–	100	80	230
Cove-Fort Sulphurdale, UT	–	–	–	50	–	50	–	50	50	1300	1,500
Leach, NV	–	–	–	–	–	50	–	–	50	1400	1,500
Roosevelt Hot Springs, UT	–	50	–	–	50	–	50	–	100	750	1,000
Safford, AZ	–	–	–	–	–	50	–	–	–	50	100
Steamboat Springs, NV	–	–	–	50	–	–	50	–	100	–	200
Thermo, UT	–	–	–	–	–	–	50	–	–	450	500
Valles Caldera, NM	–	50	–	–	100	–	100	–	100	1150	1,500
GULF COAST[1]											
Acadia Parish, LA	–	–	–	–	–	50	–	–	50	250	350
Brazoria, TX	–	–	–	–	25	–	100	100	200	1800	2,225
Calcasieu Parish, LA	–	–	–	–	–	50	–	–	50	250	350
Cameron Parish, LA	–	–	–	–	–	50	–	–	50	400	500
Corpus Christi, TX	–	–	–	–	–	50	–	–	50	1550	1,650
Kenedy County, TX	–	–	–	–	–	50	–	–	50	200	300
Matagorda County, TX	–	–	–	–	–	50	–	–	50	400	500
Cumulative Generating Capacity	1678	2188	2408	3068	3668	4793	6093	6793	9143	30923	30,923
Oil Equivalent (10^3 bbl/day)	19	25	27	35	41	54	69	77	103	342	
Associated Methane (10^6 SCF/day)	–	–	–	–	21	269	351	434	848	4858	

[1] Pilot plants are not included in this table.

[2] MITRE-assumed plant capacities for analysis. These capacities are not included in the cumulative generating capacity total.

TABLE 11

ANTICIPATED WELL AND PLANT CONSTRUCTION SHCEDULE FOR 50 MWe POWER PLANT OPERATION

KGRA AREA	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	
I. BEOWAWE														
On-Line Power (MWe)			Plant #1 →			50	Plant #2 →		50	Plant #3 →	50	#4 & #5 →	100	? →
Exploration Wells	5				5		5		5	5	5	5	5	
Production Wells				11			11		11		22	22	22	
Re-Injection Wells				5			5		5		10	10	10	
Replacement Wells						1	1	1	2	2	3	3	5	
II. BRADY														
On-Line Power (MWe)			Plant #1 →			50	Plant #2 →		50	Plant #3 & #4 →	100	#5 & #6 →	100	? →
Exploration Wells	5			5			5		5	5	5	5	5	
Production Wells				15			15		30		30	30	30	
Re-Injection Wells				7			7		14		14	14	14	
Replacement Wells						2	2	2	4	4	7	7	10	
III. STEAMBOAT														
On-Line Power (MWe)				Plant #1 →				50		Plant #2 →	50	#3 & #4 →	100	? →
Exploration Wells							5		5					
Production Wells			10			16			16		32			
Re-Injection Wells						7			7		14			
Replacement Wells								2	2	2	4	4	7	
IV. LEACH														
On-Line Power (MWe)					Plant #1 →					50	Plant #2 →		50	? →
Exploration Wells					10				5	5	5	5	5	
Production Wells								24			24	48	48	
Re-Injection Wells								10			10	20	20	
Replacement Wells										2	2	2	4	
V. DIXIE VALLEY*														
On-Liner Power (MWe)				Plant #1 →			50	Plant #2 →		50	Plant #3 & #4 →		100	? →
Exploration Wells		2	3	3	3	3		3	4	5	5	5	5	
Production Wells					13			13			26	26	26	
Re-Injection Wells					6			6			12	12	12	
Replacement Wells							2	2	2	2	6	6	6	

*Preliminary estimate only. Based on limited data when compared to other KGRA's.

Exploration Wells

The number of exploration wells drilled for developing the first 50 MWe plant in Dixie Valley depends heavily on how effectively and how soon the reservoir's structural and other geologic conditions can be defined. Based on U.S. Department of Energy evaluations, approximately 5 to 10 reconnaissance wells may be required before a fieldsite can be established for development drilling of production wells. Table 11 also includes our estimates of the necessary exploration activity in Dixie Valley over the next 12 years.

Production and Reinjection Wells

The determination of the number of production and reinjection wells necessary to support one 50 MWe plant is based upon the temperature of the produced reservoir and the produced flow rate. The following data are used herein:

Area	Temperature (°C)	MWe/Well	No. of Wells
1. Brady Hot Springs	214	3.33	15
2. Beowawe	240	4.55	11
3. Dixie Valley	225	3.85	13

Replacement Wells

Geothermal production wells begin to decrease in power production almost as soon as they are brought online. Replacement wells must be drilled and completed to provide constant heat input for the plant.

Based on experience in The Geysers and other areas, approximately 10% of the production wells in service will be replaced each year.

Drilling Costs

Although drilling costs depend upon each site's unique geological characteristics and associated inherent potential subsurface problems, costs have been estimated by the U.S. Department of Energy for nearby areas (see Tables 12 and 13); we have revised our estimation of well costs for Dixie Valley (see Table 13).

The effects of cost reductions of geothermal development derived from 1) research, development and drilling advances and, 2) Federal tax incentives within the next few years will play a major role in geothermal development in the United States. The "busbar" costs of electricity (producer plus utility costs to consumer) from competing resources (coal and nuclear) will also play a major role in regional geothermal development. Table 14 summarizes the expected costs of such competition, against which geothermal development must be measured.

Figures 13 through 17 illustrate the relative effects of research, development and drilling advances (R, D & D) and of federal tax incentives (22% depletion and expensing intangible drilling costs) on cost of electricity from liquid-dominated geothermal prospects. Investment tax credit incentive is also under consideration for revision in geothermal projects. It should be noted that the indicated cost of coal and nuclear power are conservative while the cost of geothermal power is estimated to be high because of uncertainties in development and production technology. However, existing technology (without any cost

TABLE 12

FOOTAGE COSTS FOR GEOTHERMAL DRILLING
AS A
FUNCTION OF ROCK TYPE AND WELL DEPTH

ROCK HARDNESS	COST/FOOT (1977 DOLLARS)	
	<5000 FEET	>5000 FEET
Soft	80	160
Medium	100	120
Medium-Hard	125	250
Hard	200	400

TABLE 13
GENERAL CHARACTERISTICS AND WELL COSTS FOR SELECTED GEOTHERMAL PROSPECTS

Notes	Prospect	Reservoir Temperature (°C)	Depth to Reservoir km	Average Classification [20]	Depth to Reservoir Plus 0.5 km	Probable Cost Per Exploration, Production and Replacement Well ($x10^3)	Probable Cost Per Reinjection Well ($x10^3)
4	Geysers (steam), CA	~240	2.0	Medium	2.5	1003	1003
3,4	Brazoria, TX	146	4.0	Soft	4.5	1962	1962
2	Salton Sea, CA	340	1.0	Soft	1.5	400	400
	Valles Caldera, NM	240	1.0	Hard	1.5	984	984
	Brady, NV	214	0.5	Hard	1.0	656	656
2	Brawley, CA	260	1.5	Soft	2.0	400	400
	Roosevelt, UT	230	0.8	Medium-Hard	1.3	533	533
	Beowawe, NV	240	1.0	Hard	1.5	984	984
	Coso, CA	220	1.0	Medium-Hard	1.5	615	615
	Mono-Long Valley, CA	220	1.0	Medium-Hard	1.5	615	615
1	Cove Fort/Sulphurdale, UT	200	1.5	Medium-Hard	2.0	1523	1015
1	Heber, CA	190	1.0	Soft	1.5	600	400
4	Geysers (hydro), CA	no data	2.0	Medium	2.5	1141	1141
1	East Mesa, CA	180	1.0	Soft	1.5	600	400
	Steamboat, NV	210	0.3	Medium-Hard	0.8	328	328
1	Surprise Valley, CA	175	1.0	Medium-Hard	1.5	923	615
1,4	Chandler, AZ	178	2.0	Medium	2.5	1711	1140
1,4	Leach, NV	170	2.0	Medium-Hard	2.5	2138	1426
3,4	Calcasieu Parrish, LA	156	4.0	Soft	4.5	1962	1962
1,4	Bruneau-Grandview, ID	200	2.0	Medium-Hard	2.5	2138	1426
	Lassen, CA	240	1.0	Medium-Hard	1.5	615	615
3,4	Kenedy County, TX	168	4.0	Soft	4.5	2590	2590
1	Alvord, OR	200	1.5	Hard	2.0	2437	1625
3,4	Matagorda, TX	146	4.0	Soft	4.5	1962	1962
3,4	Cameron, LA	140	4.0	Soft	4.5	2662	2662
3,4	Acadia, LA	164	4.0	Soft	4.5	1962	1962
3,4	Corpus Christi, TX	169	4.0	Soft	4.5	2000	2000
1,4	Safford, AZ	200	2.0	Medium-Hard	2.5	2138	1426
1	Weiser/Crane Creek, ID	160	1.0	Medium-Hard	1.5	923	615
1	Vale, OR	160	1.0	Soft	1.5	591	394
1	Thermo, UT	200	1.5	Medium	2.0	1219	812
1	Raft River, ID	140	1.5	Soft	2.0	910	607
4	Glass Mountain, CA	210	2.0	Medium-Hard	2.5	1426	1426
4	Puna, HI	275	2.0	Hard	2.5	2281	2281
	Mt. Hood, OR	125	1.0	Medium	1.5	738	492
1,4	Baker Hot Springs, WA	165	2.0	Medium-Hard	2.5	2138	1426
4	W. Yellowstone, WY	no data	2.0	Soft	2.5	912	912
2,4	Dixie Valley	225	1.3	Hard	1.8	1180	780

NOTES -

1 - binary plant
2 - binary or flash plant
3 - geopressured
4 - depth to reservoir estimated

TABLE 14

LEVELIZED BUSBAR COSTS OF ELECTRICITY FROM
COAL AND NUCLEAR SOURCES
(1977 mills/kWhr)

PLANT-ON-LINE DATE AND SCENARIO	CENSUS REGION/PLANT TYPE			
	PACIFIC		MOUNTAIN	
	COAL	NUCLEAR	COAL	NUCLEAR
1985 National Energy Plan[1]	27.0	--	20.0[2]	--
1985 Recent Trends Scenario	21.5	--	16.7	--
1985 High Escalation[1]	--	24.5	--	23.2
1985 Low Escalation	--	22.2	--	20.9
1990 National Energy Plan[1]	28.1	--	20.6	--
1990 Recent Trends Scenario	22.8	--	17.5	--
1990 High Escalation[1]	--	27.0	--	25.7
1990 Low Escalation	--	23.4	--	22.3

[1] Denotes alternative chosen as a basis for comparing geothermal costs.

[2] Underlined values represent the sources which are expected to be the main competitors to geothermal energy in the respective regions.

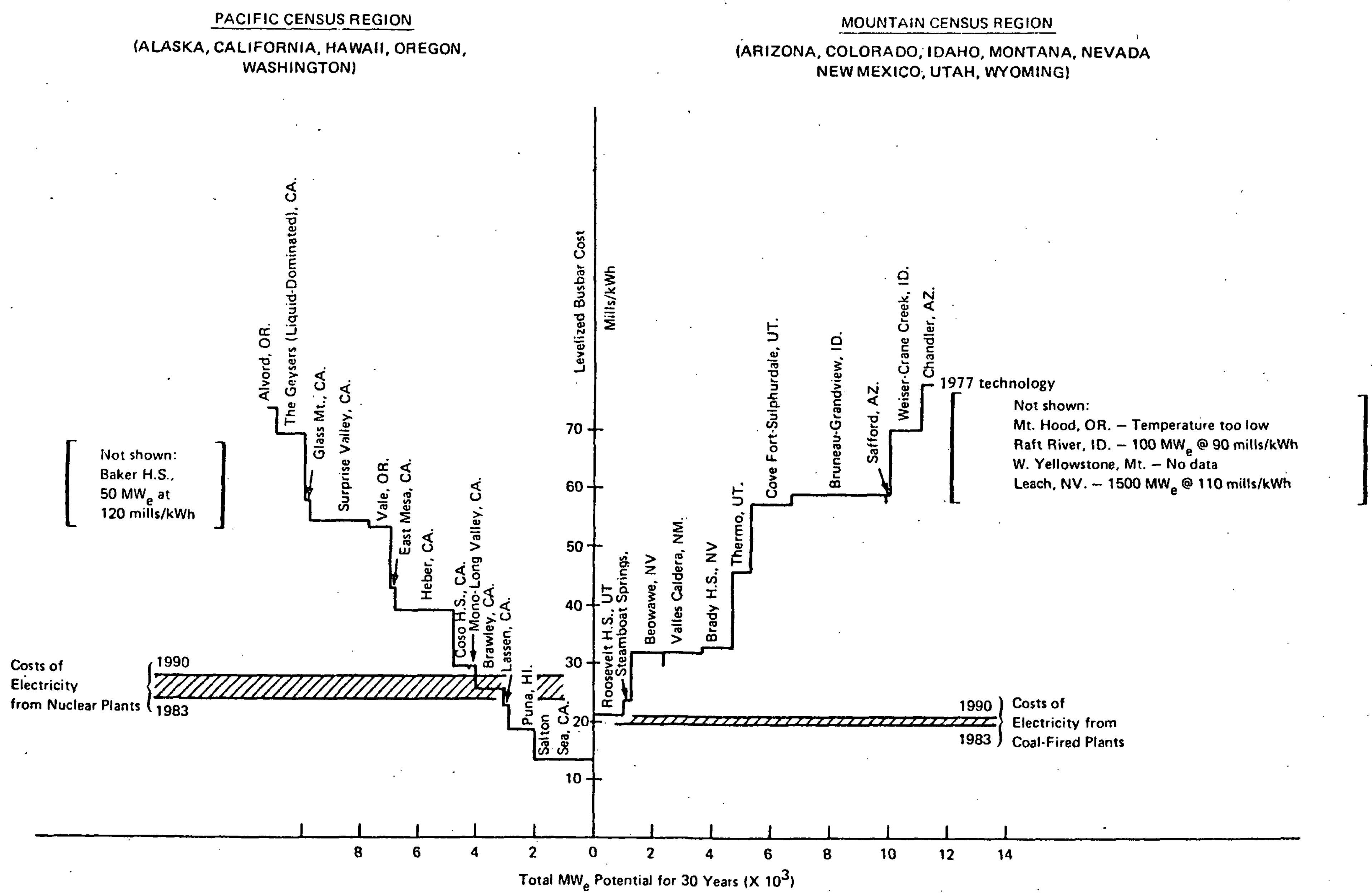


FIGURE 13: ASSUMED POTENTIAL CAPACITY vs. COST FOR ELECTRICITY FROM HYDROTHERMAL LIQUID-DOMINATED PROSPECTS WITHOUT RD&D ADVANCES

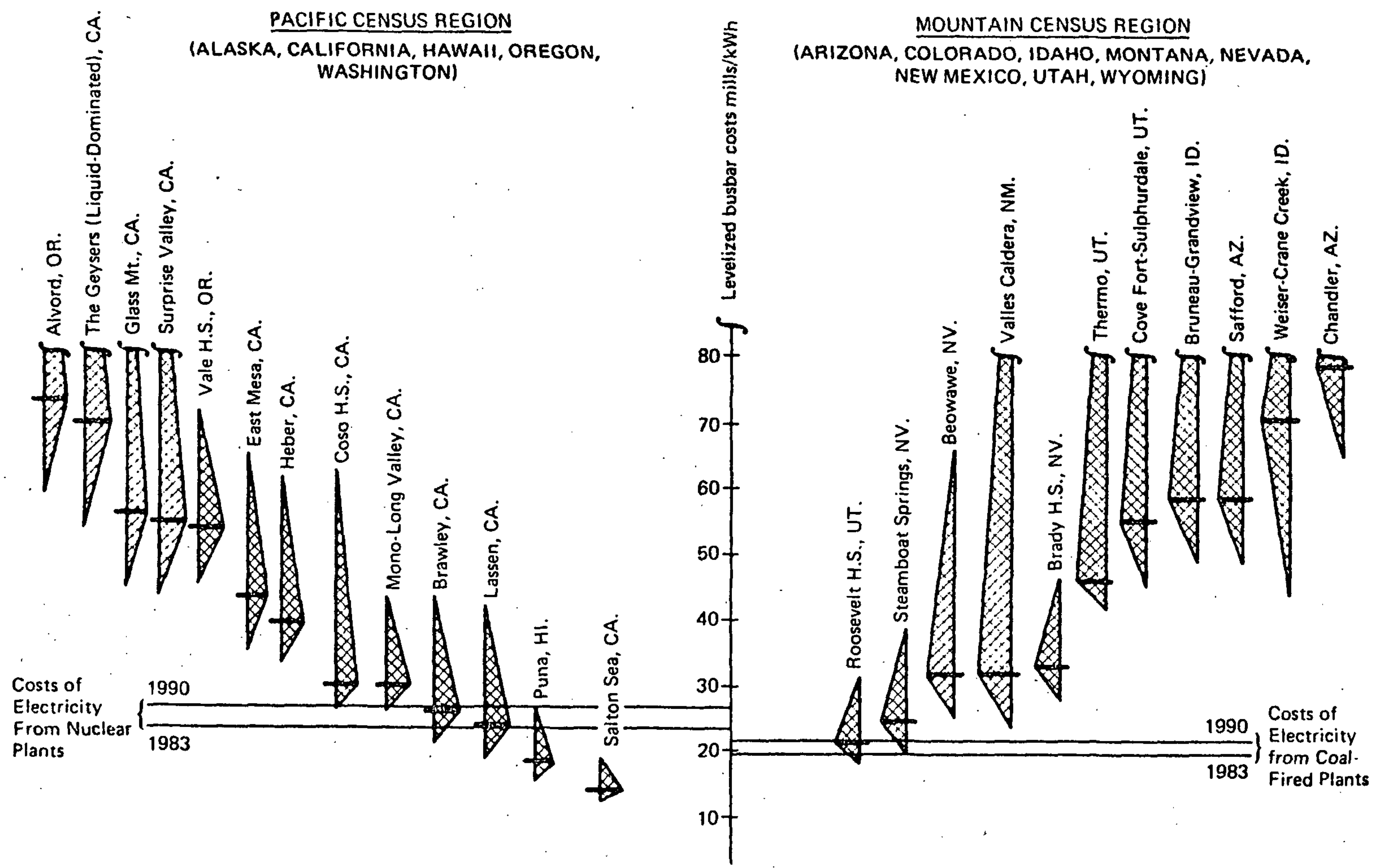


FIGURE 14: RANGES OF PROJECTED COSTS OF ELECTRICITY FROM HYDROTHERMAL LIQUID DOMINATED PROSPECTS (WITHOUT RD&D ADVANCES)

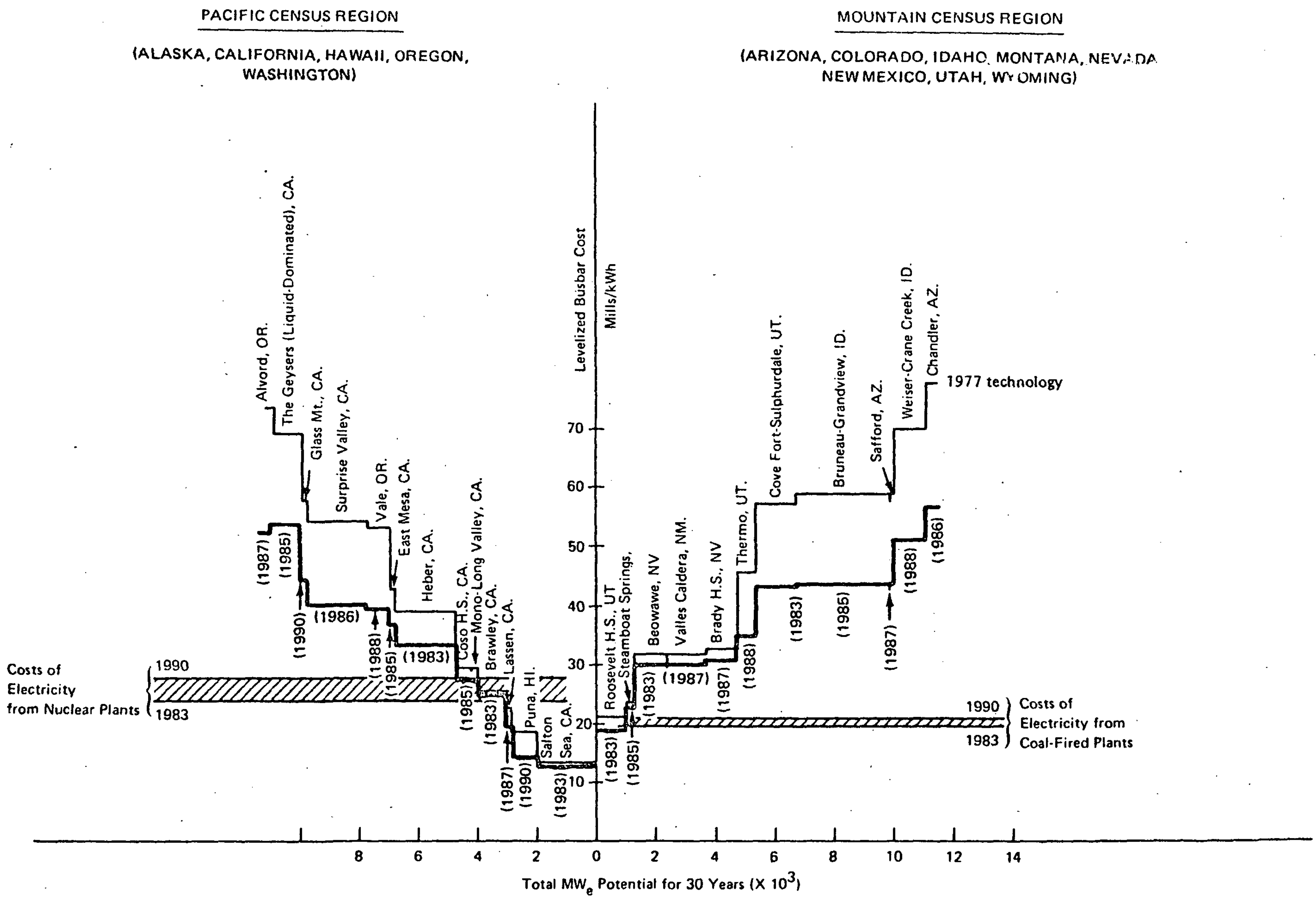


FIGURE 15: ASSUMED POTENTIAL CAPACITY vs. COST FOR ELECTRICITY FROM HYDROTHERMAL LIQUID-DOMINATED PROSPECTS (FIRST COMMERCIAL-SCALE PLANTS WITH RD&D ADVANCES)

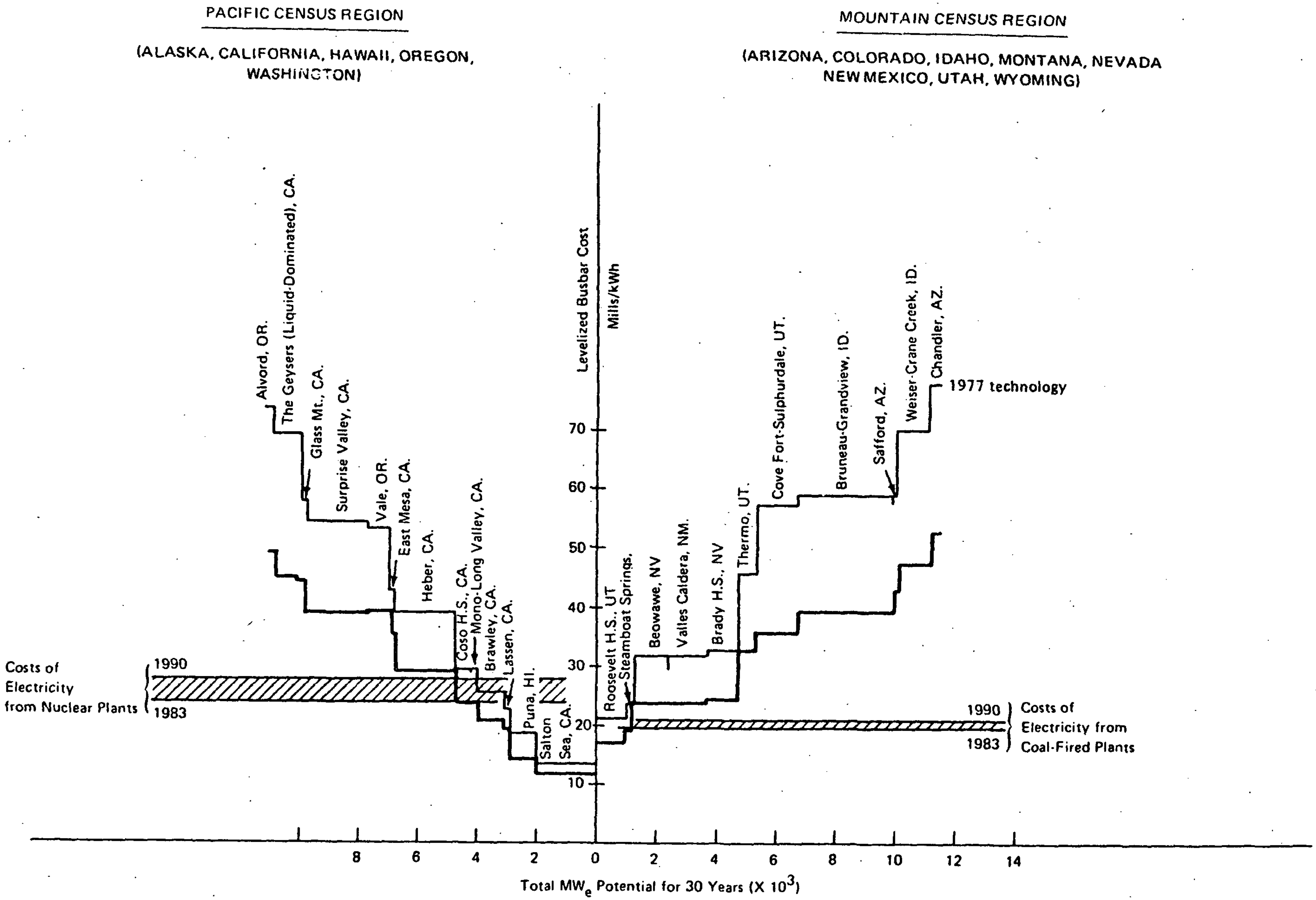


FIGURE 16: ASSUMED POTENTIAL CAPACITY vs. COST FOR ELECTRICITY FROM HYDROTHERMAL LIQUID-DOMINATED PROSPECTS WITH RD&D ADVANCES

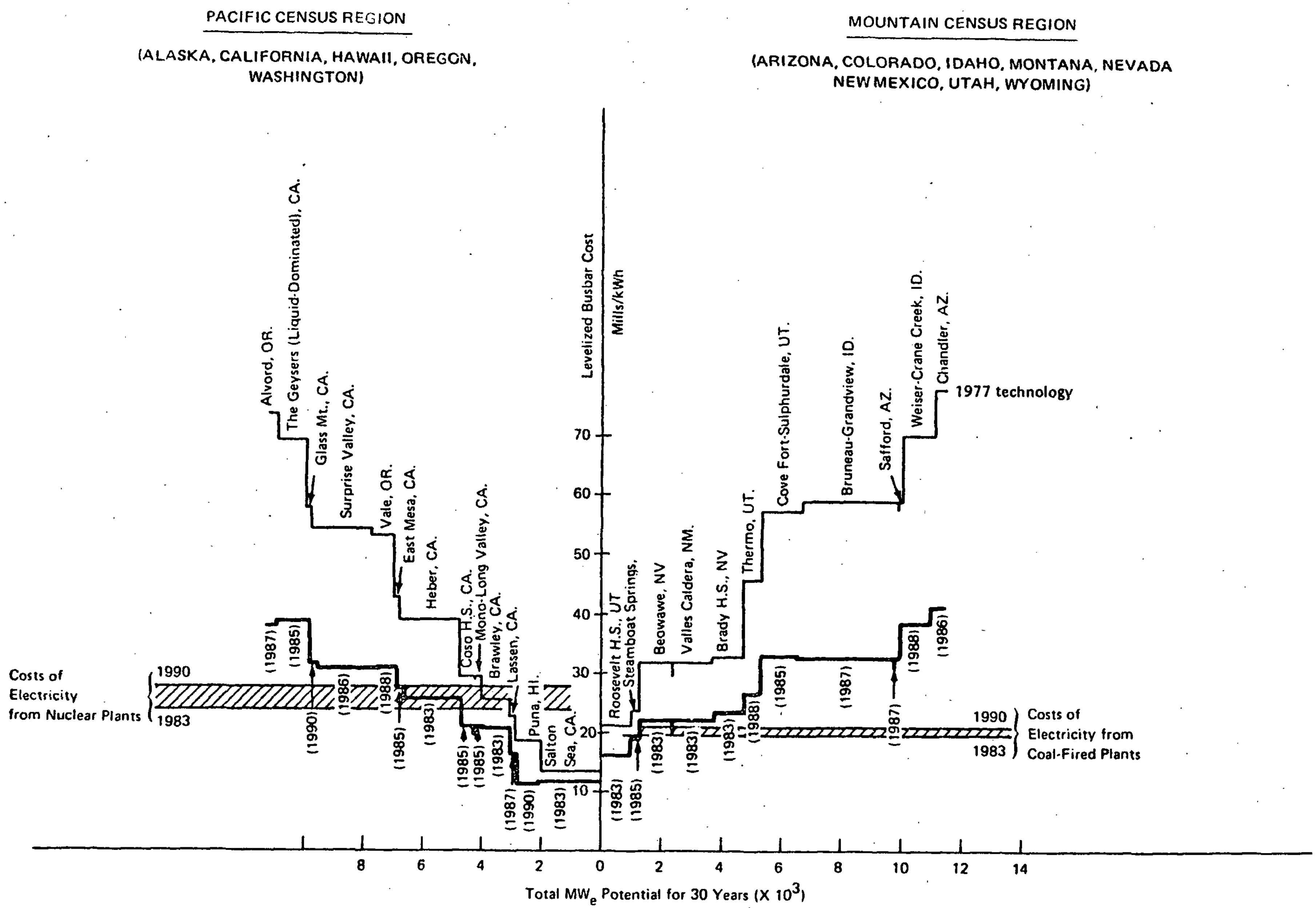


FIGURE 17: ASSUMED POTENTIAL CAPACITY vs. COST FOR ELECTRICITY FROM HYDROTHERMAL LIQUID-DOMINATED PROSPECTS—FIRST PLANTS ON LINE WITH RD&D ADVANCES, 22% DEPLETION ALLOWANCE AND EXPENSING INTANGIBLE DRILLING COSTS

reductions in the future) is capable of making geothermal generally competitive during the 1980's if coal and nuclear power experience any form of unforeseen price escalation. If cost reductions do occur, geothermal energy will become a significant source of energy for the entire western United States.

VI. CONCLUSIONS

It is very apparent that Dixie Valley has significant geothermal potential. Furthermore, although early indications were not as dramatic as nearby areas (e.g. high spring and geothermetric temperatures), Dixie Valley has a potential for future development very similar to that of Brady Hot Springs and Beowawe KGRA's.

Timing is important in any resource development project. It is a prime favorable factor in the development of Dixie Valley. The area's exploration and development can draw heavily from the experiences of nearby areas, which will no doubt result in reduced costs relative to those projects preceding it. Early signs of Dixie Valley's economic viability (or the lack of it) will be apparent. In addition, the Federal Government may revise tax incentives to promote growth of geothermal development. The timing of this revision, if one is made, will certainly affect Dixie Valley and its future viability.

Based on the geologic evaluations of Dixie Valley to date, the following conclusions can be drawn:

1) Two shallow heat sources have been identified along the western border of Dixie Valley within land held by Millican Oil Company. A third heat source, also within Millican holdings, is possible on the eastern boundary of the valley.

2) Thermal gradient drilling near one of the heat sources suggests subsurface temperatures greater than 200°C at depths of 3,000 to 4,000 feet in the fractured metasedimentary units below the gabbroic complex. A liquid-dominated reservoir is expected. However, a reservoir at depths greater than 8,000 feet may be steam-dominated because of the very high temperatures indicated, but exploration is not sufficiently advanced at this time to suggest such a condition.

3) Faulting is widespread and complex within the basin which allows for numerous avenues of upwelling heated ground water to reach intervals within economic drilling depths, i.e. less than 9,000 feet, depending upon the temperature and flow rate encountered.

4) Ground-water geochemistry may be similar to Brady Hot Springs and Beowawe areas, and thus may present sealing and scaling problems during the development of the reservoir.

5) Although remote from population centers, the Dixie Valley area is located approximately 30 miles north of a 230 KV power line.

6) Land position of Millican Oil Company is excellent. Assuming a minimum of 7 sections (4,500 acres) of production, approximately six 50 MWe plants could be supported via substained total production of 300 MWe over a 30-year period. Balanced land position allows a widespread coverage of the various structural plays in the area.

7) Per well initial production of 475,000 pounds/hr. (3.85 MWe/well) is necessary for economic viability and appears possible at this time, although drilling must be undertaker to substantiate such potential.

8) A production temperature of 225°C appears possible at this time, if temperature gradient of previously drilled well (H-1) represents a somewhat less than linear relationship with depth.

9) Flash production may be appropriate for any production temperatures in excess of 200° C.

10) Future exploration and development in Dixie Valley will be considerably enhanced by the industrial-academic project presently being seriously considered by U. S. Department of Energy.

11) It should be noted that many of the quantitative conclusions made herein are clearly based on limited and speculative information at a stage of the project where such probabilities must be considered in view of assessing risk. We reserve the right to alter our conclusions as additional data become available.

VII. REFERENCES

Armstead, H. C., 1973, "Geothermal Engergy, Review of Research and Development"; Unesco Press, 186 p.

Anon., 1978, "Proposal on Geothermal Reservoir Assessment Case Study Northern Basin and Range Province", Dept. of Energy, RFP ET-78-R-U8-0003, Millican Oil Company, Southland Royalty Company and University of Nevada at Reno, 160 p.

Bhattacharyya, B.K. and L.K. Leu, 1975, "Analysis of Magnetic Anomalies Over Yellowstone National Park: Mapping of Curie Point Isothermal Surface for Geothermal Reconnassance", Journ. Geophy. Res., Vol. 80, No. 32, pp. 4461-4465.

Goldstein, N. E., 1977, "Northern Nevada Geothermal Exploration Strategy Analysis", L.L.L. Labs Report 7012, U. S. Department of Energy, TID - 4500-R66, 55 p.

Gupta, J. N. and J. G. Leigh, 1978, "Gelcom, A Geothermal Levelized Busbar Cost Model, Description and User's Guide", Mitre Corporation, Report M78-17, January, 127 p.

Keplinger and Associates, Inc., 1977, "A Preliminary Evaluation of The Hughes Geothermal Properties in Churchill County, Nevada", Report for Millican Oil Company, April 21, 65 p.

Keplinger and Associates, Inc., 1977, "Phase II Preliminary Evaluation of Dixie Valley, Nevada: Geothermal Potential and Associated Economics", Report for Millican Oil Company, September 16, 1977, 46 p.

Leigh, J., et.al., 1978, "Site-Specific Analysis of Geothermal Development", Volume 1, Summary Report, U. S. Department of Energy, Div. Geothermal Energy, Mitre Corporation, Washington, D. C., DGE/4014-2, August, 58 p.

Mitre Corporation, 1978, "Prospects for Improvement in Geothermal Well Technology and Their Expected Benefits", for U. S. Department of Energy, HCP/T4014-04, June, 128 p.

Pearl, R. H., 1976, "Hydrological Problems Associated with Developing Geothermal Energy Systems", Ground Water, Vol. 14, No. 3, May - June, pp. 128-137.

Sacarto, D. M., 1976, "State Policies for Geothermal Development", National Conference of State Legislators, Denver, 94 p.

Senturion Sciences, Inc., 1977, "High-Precision Multilevel Aeromagnetic Survey Over Dixie Valley", Report for Southland Royalty Company and Millican Oil Company, October, 15 p.

Senturion Science, Inc., 1978 "Part 2 - High Precision Multilevel Aeromagnetic Survey Over Dixie Valley", Report for Southland Royalty and Millican Oil Company, June, 13 p.

Senturion Sciences, Inc., 1978, "South Dixie Valley, Nevada: Scalar Magnetotelluric Survey", Report for Southland Royalty and Millican Oil, February, 45 p.

Trehan, R., et al, 1977, "Site-Specific Analysis of Geothermal Development - Scenarios and Requirements", Volume II, Mitre Corporation Report MTR-7586, April, 655 p.

Williams, F., et.al., 1977, "Site-Specific Analysis of Geothermal Development - Data Files of Prospective Sites", Volume III, Mitre Corporation Report MTR-7586, October,620 p.

KEPLINGER and Associates, inc.

VIII APPENDIX

DEVELOPMENT SCENARIOS
AND
SITE-SPECIFIC ANALYSIS
OF
SELECTED
PROSPECTIVE GEOTHERMAL AREAS
IN NEVADA:

A) BRADY HOT SPRING KGRA

B) BEOWAWE KGRA

C) STEAMBOAT SPRINGS KGRA

D) LEACH KGRA

BRADY HOT SPRINGS, NEVADA

Postulated Development Scenario

PLANT NUMBER	INSTALLED CAPACITY (MWe)	PLANT ON-LINE DATE
1	50	1983
2	50	1986
3	100	1988
4	100	1990
SUBSEQUENT PLANTS	700	1991-1997
TOTAL	1000	to 1997

Estimate of Resource Characteristics

RESOURCE CHARACTERISTIC	ESTIMATE
Subsurface Fluid Temperature (°C)	Range: 200-230 Best Estimate: 214
Total Dissolved Solids (PPM)	2,450
Electric Energy Potential (MWe 30 years)	1,000
Overlying Rock	Hard: Basalt and alluvium
Depth to Top of Reservoir (Meters)	500
Land Status	
Total KGRA acres	98,508
Total Federal acres	59,358
Federal acres leased	26,049[1]
Total State and private acres	39,150
State and private acres leased	No data

[1] All Federal land in the KGRA was offered in the Federal lease sale.

Development Status and Activity

Several companies have been drilling in the area since 1959. Magma Power Company drilled several shallow wells between 1959 and 1961. Earth Energy, Inc. drilled a well to 1,519 meters (5,062 feet) in 1964. By August 1975, Phillips Petroleum Company and Union Oil Company had drilled deeper than 2,100 meters (7,000 feet) and Magma had drilled two wells, one to 1,050 meters (3,500 feet) and the other to 1,350 meters (4,500 feet) near the old holes.

By February 1977, Southern Union Products company had suspended operation and Standard Oil of California had drilled a producing well.

One 1,500 meter (4,900 foot) well had a temperature of 214°C and a high flow rate.

Phillips has new high-flow-rate wells east of the old Brady Magma wells.

In 1977, ERDA (now part of DOE) approved an application for $3.46 million in loan guarantees by Geofood Products, Inc., to build a plant to use heat from the Brady geothermal resource for dehydration of food products. Total project cost is $4.96 million. The loan has been granted by the Nevada National Bank.

Major Development Problems

There do not appear to be any severe technological problems at Brady Hot Springs. However, the following determinations must be made before development can begin:

- Whether or not the brine at Brady may lead to severe calciting, as has been suggested may happen.
- What the noncondensible content is, as this may affect the choice of conversion technology.

Also, injection feasibility must be demonstrated, and the maintenance of production flow must be demonstated in formations having low permeabilities.

Postulated Development Scenario: Status and Implications

First Commercial-Scale Plant: 50 MWe in 1983

The postulated development schedule at Brady Hot Springs calls for a 50-MWe plant to begin in operation in 1983. The development schedule appears in Figure 22-1. As shown, the commitment to develop the site must be made at the beginning of 1979 while plant design must be completed in mid-1980 to achieve power on line in 1983. The required timing for the availability of new technology would thus be 1980. A complementary schedule in Figure 22-2 presents the activities of principal paricipants in the development of the series of plants postulated for Brady Hot Springs. It is anticipated that this plant will use flash cycle conversion technology because:

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
BLM	Issue STC Drilling Permit	Developer	ASSUMED COMPLETED										
County	Issue Land Use Permit	Developer											
USGS	Issue Drilling Permit	Developer											
BLM	Lease Land	Developer											
BLM	Process EIA/EIS	CEQ											
Developer	Exploratory Drilling & Reservoir Evaluation		—	—									
Developer	Develop Utility Interest		—										
Developer & Utility	Feasibility Study		—	—									
Producer (Developer) & Utility	Financial Negotiations			—									
Producer	Site Selection			—									
Producer & Utility	Design				—	—							
Producer & Utility	Commitment to Development				△								
Producer & Utility	Prepare Master Development Plan	BLM USGS			—								
Utility	Prepare Environmental Data Statement	BLM FPC State, County			—								
BLM, FPC, State	Certify Plant & Site, Issue Permits	Producer & Utility			—	—	—						
USGS													
USGS	Process EIA/EIS (Drilling	CEQ			—	—							
FPC	Process EIA/EIS (Plant)	CEQ			—	—							
FPC	Process EIA/EIS (Transmission Line)	CEQ			—	—							
Producer	Development Drilling						—	—	—				
Utility	Plant Construction						—	—	—				
Utility	Install Transmission Line (16km)						—	—	—				

FIGURE 22-1
DEVELOPMENT SCHEDULE FOR FIRST PLANT: BRADY HOT SPRINGS, NEVADA
(FEDERAL LAND)

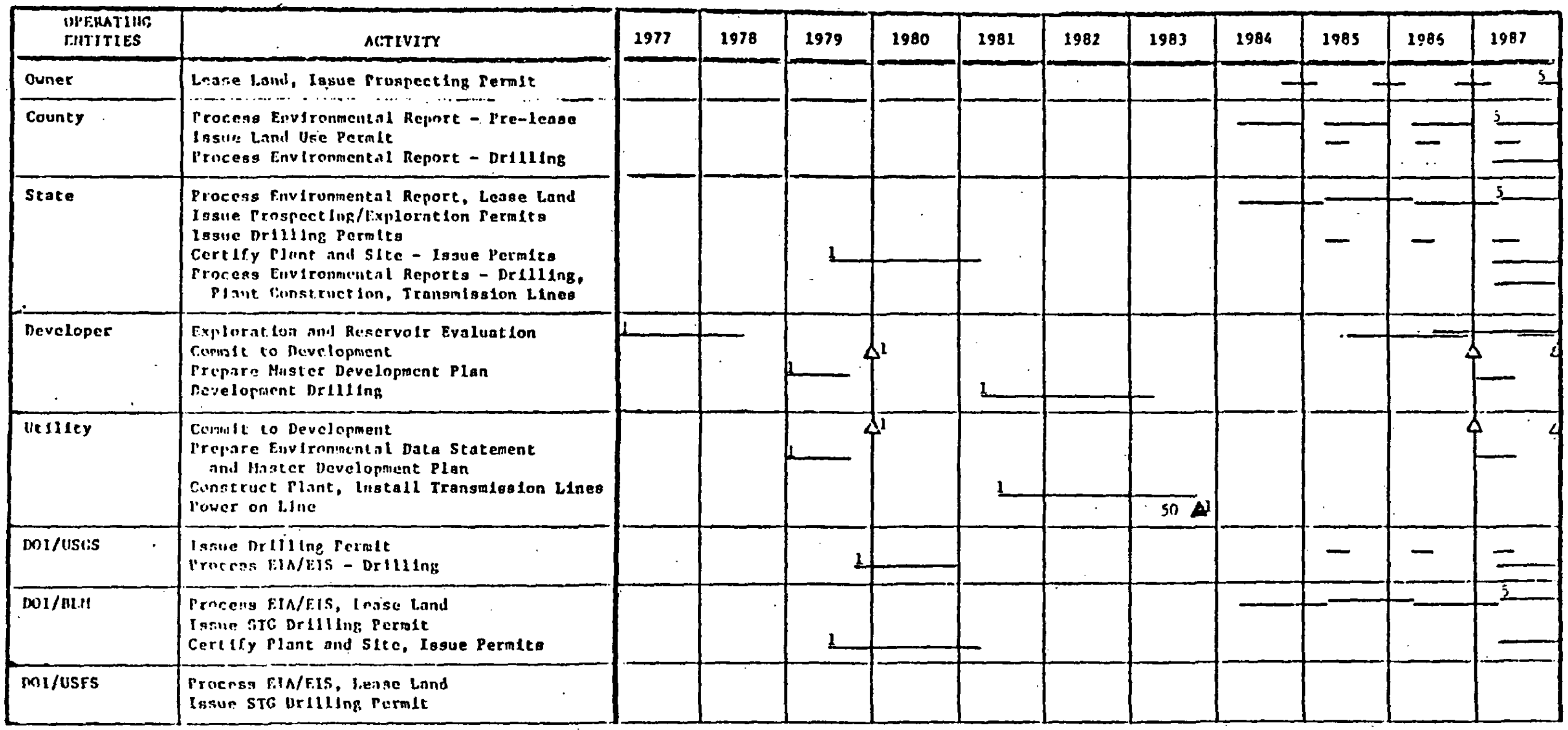


FIGURE 22-2
DEVELOPMENT SCHEDULE FOR ALL PLANTS: BRADY HOT SPRINGS, NEVADA

OPERATING ENTITIES	ACTIVITY	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Owner	Lease Land, Issue Prospecting Permit											
County	Process Environmental Report - Pre-lease											
	Issue Land Use Permit											
	Process Environmental Report - Drilling											
State	Process Environmental Report, Lease Land											
	Issue Prospecting/Exploration Permits											
	Issue Drilling Permits											
	Certify Plant and Site - Issue Permits											
	Process Environmental Reports - Drilling, Plant Construction, Transmission Lines											
Developer	Exploration and Reservoir Evaluation											
	Commit to Development											
	Prepare Master Development Plan											
	Development Drilling											
Utility	Commit to Development											
	Prepare Environmental Data Statement and Master Development Plan											
	Construct Plant, Install Transmission Lines											
	Power on Line			100▲	100▲	100▲	100▲	100▲	100▲	100▲	100▲	
DOI/USGS	Issue Drilling Permit											
	Process EIA/EIS - Drilling											
DOI/BLM	Process EIA/EIS, Lease Land											
	Issue STG Drilling Permit											
	Certify Plant and Site, Issue Permits											
DOI/USFS	Process EIA/EIS, Lease Land											
	Issue STG Drilling Permit											

FIGURE 22-2 (CONCLUDED)

- Reservoir temperature appears high enough to give flash technology an economic advantage over binary; and
- Flash technology may appear to the developers to be less risky than binary in this time frame.

However, certain resource characteristics which are not known at present may affect the choice of technology. Possible high noncondensible gas content (>3 percent) might necessitate a binary cycle, because noncondensible gases in a flash system require high pumping power to remove the gases from the condenser. Calciting tendencies in the brine might lead to problems of scaling.

In the context of a possible binary plant, the experience gained at the Niland thermal loop will be relevant. The problems associated with binary systems are described in detail under Salton Sea, California. In the following, the use of a flash cycle plant is assumed.

Development Problems. This plant would be one of the first flash geothermal plants constructed in the United States and, in the absence of experience with similar type plants, is likely to be perceived as a relatively high-risk venture. The schedule requires that a utility company be identified in mid-1977, commitment to development be made in early 1979, design be completed by mid-1980, and construction started by mid-1981. While the attitude to development in the area is relatively favorable, mild constraints and brief delays may be anticipated.

Reservoir conditions appear fairly good. High flow rates are reported to have been obtained from test wells, although no numerical data are available. A low TDS of 2450 ppm has been reported. It is believed that the major problems associated with this and other similar reservoirs in Nevada are high noncondensible gas content, possible calciting tendencies of the brine, and maintenance of production well flow from low permeability reservoir formations.

Drilling in the hard rocks associated with this reservoir may be difficult, but is well within current capabilities. Well completions at the estimated reservoir temperature of 214°C should present no problems. Wells have been successfully completed under much more severe conditions (Salton Sea, Cerro Prieto, The Geysers). Since some good well flows have been demonstrated, it is not expected that deep well pumps will be required, although control of noncondensible gases and/or calciting might necessitate their use.

Since flash plant conversion technology has been demonstrated elsewhere in the world, no severe technological problems are foreseen. Before the development can proceed, it will be necessary to demonstrate injection of spent brine in this fractured volcanic rock environment, but this is expected to be feasible. Table 22-I shows a summary of important site-related needs and RD&D impacts.

In summary, while it appears that there are no initial technological obstacles to development on the postulated schedule, additional

TABLE 22-I
ECONOMIC ANALYSIS: BRADY HOT SPRINGS, NEVADA
FLASH SYSTEM , 50 MW ELECTRIC PLANT
FIRST PLANT ON LINE DATE : 1983

TEMPERATURE IN CENTIGRADE DEGREES (BEST ESTIMATE) : 214
WELL DEPTH IN METERS : 1000
BRINE SALINITY : LOW
OVERLYING ROCK TYPE : HARD
THE WELL FLOW RATE IS NOT SPECIFIED : THE DEFAULT FLOW RATE USED (KGM./HR.) = 205886
THE COST PER PRODUCTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER PRODUCTION WELL ($) = 656168.1
THE COST PER INJECTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER INJECTION WELL ($) = 656168.1

PRODUCER FINANCIAL DATA

DEBT FRACTION :	0.30
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.20
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.10
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF PRODUCTION WELLS (YEARS) :	10.00
LIFE SPAN OF INJECTION WELLS (YEARS) :	10.00
LIFE SPAN OF PRODUCER PLANT (YEARS) :	20.00
START UP COST MULTIPLIER :	1.081

UTILITY FINANCIAL DATA

DEBT FRACTION :	0.50
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.12
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.0
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF UTILITY PLANT (YEARS) :	30.00
ULTIMATE CAPACITY FACTOR :	0.80
START UP COST MULTIPLIER :	1.038

* NUMBER OF WELLS , CAPITAL COSTBASIS AND O&M COSTS , AND REVENUE REQUIREMENTS WITHOUT ANY R&D IMPACTS *

CAPITAL COSTBASIS (1977 $M)

15 PRODUCTION WELLS :	11.848	
7 INJECTION WELLS :	5.529	
PRODUCER PLANT EXCLUDING WELLS :	6.149	
REPLACEMENT PRODUCTION WELLS :	10.118	
REPLACEMENT INJECTION WELLS :	4.722	
REPLACEMENT PLANT :	2.713	
TOTAL FOR PRODUCTION FIELD :		41.079
GENERATING PLANT :		25.814
TOTAL :		66.894

O&M COSTS (1977 $M/YR.)

PRODUCER		
GENERAL :	0.401	
WELL :	0.144	
DEEP WELL PUMP :	0.0	
SPENT BRINE TREATMENT :	0.0	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.545
UTILITY		
GENERAL :	0.753	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.753

** REVENUE REQUIREMENTS **

PRODUCER : 25.382 MILLS/KWHR
UTILITY : 7.511 MILLS/KWHR
* TOTAL : 32.893 MILLS/KWHR *

TABLE 22-I (CONTINUED)

* R&D IMPACTS FOR PLANT NO. 1 - ON LINE DATE : 1983 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
CAPITAL COST PER PRODUCTION WELL	-5.00	-0.6792
CAPITAL COST PER INJECTION WELL	-5.00	-0.3170

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 22.622 MILLS/KWHR
UTILITY : 7.511 MILLS/KWHR
* TOTAL : 30.133 MILLS/KWHR *

* SENSITIVITY OF COST OF ELECTRICITY (FROM PLANT NO. 1 , R&D IMPACTS INCLUDED) *

RESOURCE & OPERATING PARAMETERS	MILLS/KWHR
HIGH RESOURCE TEMPERATURE ESTIMATE (230 DEGREES CENTIGRADE)	26.023
LOW RESOURCE TEMPERATURE ESTIMATE (200 DEGREES CENTIGRADE)	44.324
HIGH CAPACITY FACTOR VALUE : 0.85	28.360
LOW CAPACITY FACTOR VALUE : 0.60	40.177
EXPENSING OF INTANGIBLE DRILLING COSTS (70.0% OF WELL COSTS EXPENSED)	27.006
DEPLETION ALLOWANCE (22.0% OF GROSS INCOME)	25.689
INVESTMENT TAX CREDIT (26.2% GROSS, 15.0% EFFECTIVE)	28.428

* R&D IMPACTS FOR PLANT NO. 2 - ON LINE DATE : 1986 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-12.00	-1.6302
CAPITAL COST PER INJECTION WELL	-12.00	-0.7608
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0777
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0348
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0808
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0279
LIFE SPAN OF PRODUCTION WELLS	20.00	-0.9911
LIFE SPAN OF INJECTION WELLS	100.00	-1.4111
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.2158

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 19.900 MILLS/KWHR
UTILITY : 7.246 MILLS/KWHR
* TOTAL : 27.145 MILLS/KWHR *

Brady Hot Springs, NV

TABLE 22-I (CONCLUDED)

* R&D IMPACTS FOR PLANT NO. 3 - ON LINE DATE : 1988 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-12.00	-1.6302
CAPITAL COST PER INJECTION WELL	-12.00	-0.7608
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0777
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0348
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0608
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0279
LIFE SPAN OF PRODUCTION WELLS	20.00	-1.0115
LIFE SPAN OF INJECTION WELLS	100.00	-1.4299
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.2158

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 19.867 MILLS/KWHR
UTILITY : 7.246 MILLS/KWHR
* TOTAL : 27.112 MILLS/KWHR *

* R&D IMPACTS FOR PLANT NO. 4 - ON LINE DATE : 1990 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-20.00	-2.7170
CAPITAL COST PER INJECTION WELL	-20.00	-1.2679
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0777
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0348
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0608
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0279
LIFE SPAN OF PRODUCTION WELLS	20.00	-1.0115
LIFE SPAN OF INJECTION WELLS	100.00	-1.4299
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.2158

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 18.526 MILLS/KWHR
UTILITY : 7.246 MILLS/KWHR
* TOTAL : 25.772 MILLS/KWHR *

Brady Hot Springs, NV

information about reservoir and fluid characteristics might alter this perception.

Economic Analysis. The projected economics of electrical generation at the Brady Hot Springs geothermal power prospect are presented in Table 22-I. The levelized busbar cost of electricity[1] produced by a flash conversion system at this site is estimated to be 32.9 mills/kWh using currently available technology. Taking into account anticipated cost reductions from the RD&D program, the first commercial-scale plant at this site, postulated to come on line in 1983, is expected to have a levelized busbar energy cost of 30.1 mills/kWh.

It is assumed that geothermal electric plants in this region will be competing primarily for base-load generating capacity addition against coal-fired steam plants. The levelized busbar cost of electricity from these sources is expected to be about 20.0 mills/kWh for plants coming on-line in 1985, rising to 20.6 mills/kWh for plants coming on-line in 1990 under assumptions of the National Energy Plan scenario for escalation of coal prices.

It can be seen that the cost of electricity (with RD&D benefits) at this prospect is not competitive without the advantages of further incentives. The sensitivity analysis for Plant 1 shows that expensing intangible drilling costs would reduce the levelized busbar cost by about 3.1 mills/kWh, that a 22 percent depletion allowance would

[1] See Chapter 2 for details of the computer print-out and assumptions and data used in this analysis.

reduce costs by at most 4.4 mills/kWh, and that an increased investment tax credit to 15 percent effective would reduce costs by about 1.7 mills/kWh. Thus, the use of further incentives (such as an investment tax credit of approximately 25 percent plus depletion and expensing intangibles) would be required to render this plant roughly competitive on the basis of cost. Within limits, changes in the levels of the depletion allowance or tax credit would produce proportional cost changes to achieve a desired level of incentive.

Subsequent Plants

The second plant at Brady Hot Springs is scheduled to come on line in 1986. This means that the commitment to develop must be made in 1982 for design to be completed in 1984 prior to start of construction. It is clear that operating experience at Plant 1 will not be be acquired in time to have a major impact on the design of Plant 2. Moreover, on the basis of the postulated development schedule, there will be insufficient time for operating experience at any United States commercial-scale, liquid-dominated geothermal plant to influence Plant 2 at Brady Hot Springs.

Based on the impacts of RD&D shown in Table 22-I, Plant 2 is expected to have a levelized busbar cost of 27.1 mills/kWh. This indicates that the first two tax incentives (expensing intangible drilling costs and applying a 22 percent depletion allowance) would bring electricity costs to about a competitive level.

Plant 3 at Brady Hot Springs is postulated to come on line in 1988 at an estimated cost of electricity of 27.1 mills/kWh. This plant should benefit from prior operating experience at Brady Hot Springs, Beowawe, Roosevelt Hot Springs,and Valles Caldera.

Plant 4, on line in 1990, has an estimated cost of electricity of 25.8 mills/kWh.

BEOWAWE, NEVADA

Postulated Development Scenario

PLANT NUMBER	INSTALLED CAPACITY (MWe)	PLANT ON-LINE DATE
1	50	1983
2	50	1986
3	50	1988
4	100	1990
SUBSEQUENT PLANTS	750	1991-1998
TOTAL	1000	to 1998

Estimates of Resource Characteristics

RESOURCE CHARACTERISTIC	ESTIMATE
Subsurface Fluid	Range: 165-280
Temperature (°C)	Best estimate: 240
Total Dissolved Solids (PPM)	1,200
Electric Energy Potential (MWe 30 Years)	624
Overlying Rock	Hard: Tertiary basalt and Quaternary alluvium
Depth to Top of Reservoir (Meters)	1,000
Land Status	
Total KGRA acres	33,225
Total Federal acres	16,530
Federal acres leased	13,766[1]
Total State and private acres	19,112

[1] Nearly all the Federal land has been offered and leased in recent Federal lease sales.

Development Status and Activity

As of August, 1975, the deepest well drilled was 2,915 meters (9,563 feet). By June, 1976, more than 12 holes had been drilled, with Magma Power Company (Chevron) planning additional holes. By February, 1977, one well had been drilled by Standard Oil Company of California. Phillips Petroleum Company has also been involved in development.

Major Development Problems

This is an isolated site. If a purchaser/utility can be identified, then there should be no severe problems. Still it is recommended that the following potential problem areas be investigated:

- silica scaling
- return flow injectibility
- low sustained flow rates from production wells.

Postulated Development Scenario: Status and Implications

First Commercial-Scale Plant: 50 MWe in 1983

No clear-cut major leaseholder/developer of the Beowawe site has been identified. However, companies such as Chevron, Standard Oil, and Phillips Petroleum Company have leased Federal lands in the area. Based on current information, a 50-MWe flash conversion power plant appears possible at this site by 1983. However, the site is remote from population centers (20 miles to a town of 1800 people), and a utility may have marketing problems with a plant at this isolated site. Also, the site is situated about 150 miles from a primary distribution line (750 KV).

Figure 21-1 shows a possible development schedule for Plant 1 at the Beowawe site. For 1983 power-on-line, commitment to development must take place at the beginning of 1979. Final design must be completed in 1980, and the technological RD&D, to contribute to this plant, must be available at about the same time. Since Plant 1 is to undergo development in parallel with other early-phase flash conversion power plants (Valles Caldera, Brady Hot Springs, Brawley, Roosevelt Hot Springs, and possibly Salton Sea), some interrelated technology undergoing development can be shared, but no operational experience with commercial-scale plants will be available to support the Beowawe plant development.

Figure 21-2, which complements the preceding figure, shows the scheduled activities of the principal participants in the development of all the plants postulated for Beowawe.

Development Problems. Principal RD&D problems at this site include possible scaling from a high silica content in the geothermal fluid and the long-term injection of the spent brine into the fractured volcanic formation. Testing to date has indicated low reservoir permeabilities and resultant low volumetric flow rates from production wells. Reservoir stimulation technology could therefore be important at this prospect. Again, Beowawe should be able to share

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
BLM	Issue STC Drilling Permit	Developer	ASSUMED COMPLETED										
USGS	Issue Drilling Permit	Developer											
BLM/Owner	Lease Land	Developer											
BLM	Process EIA/EIS	CEQ											
County	Issue Land Use Permits	Developer											
Developer	Exploratory Drilling & Reservoir Evaluation												
Developer	Develop Utility Interest												
Developer & Utility	Feasibility Study												
Producer (Developer) & Utility	Financial Negotiations												
Producer	Site Selection												
Producer & Utility	Design												
Producer & Utility	Commitment to Development												
Producer & Utility	Prepare Master Development Plan	BLM, USGS											
Utility	Prepare Environmental Data Statement	BLM, FPC, STATE, County											
BLM, FPC State, USGS	Certify Plant & Site, Issue Permits	Producer & Utility											
USGS	Process EIA/EIS (Drilling)	CEQ											
FPC	Process EIA/EIS (Plant)	CEQ											
FPC	Process EIA/EIS (Transmission Line)	CEQ											
Producer	Development Drilling												
Utility	Plant Construction												
Utility	Install Transmission Line (40km)												

FIGURE 21-1
DEVELOPMENT SCHEDULE FOR FIRST PLANT: BEOWAWE, NEVADA
(FEDERAL LAND/POSSIBLY SOME PRIVATE)

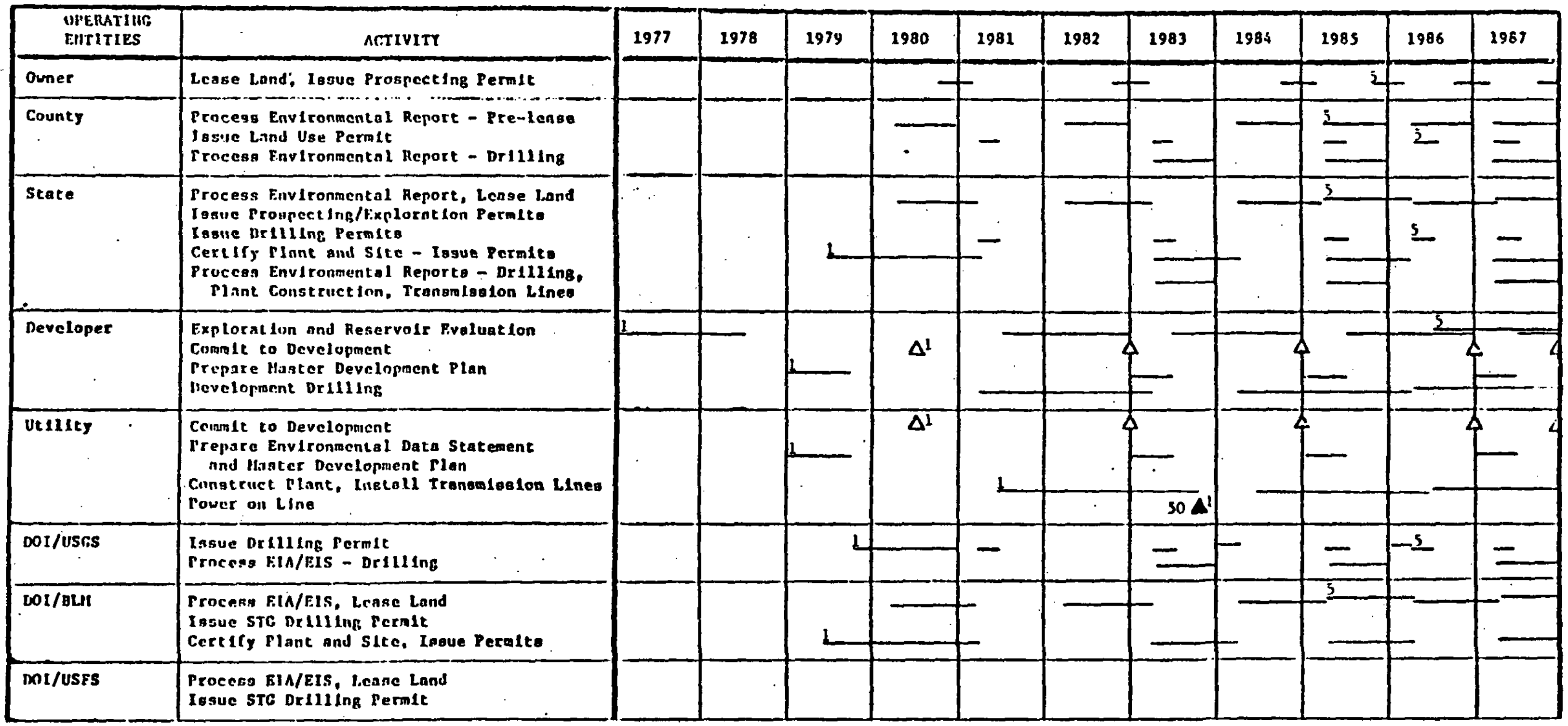


FIGURE 21-2
DEVELOPMENT SCHEDULE FOR ALL PLANTS: BEOWAWE, NEVADA

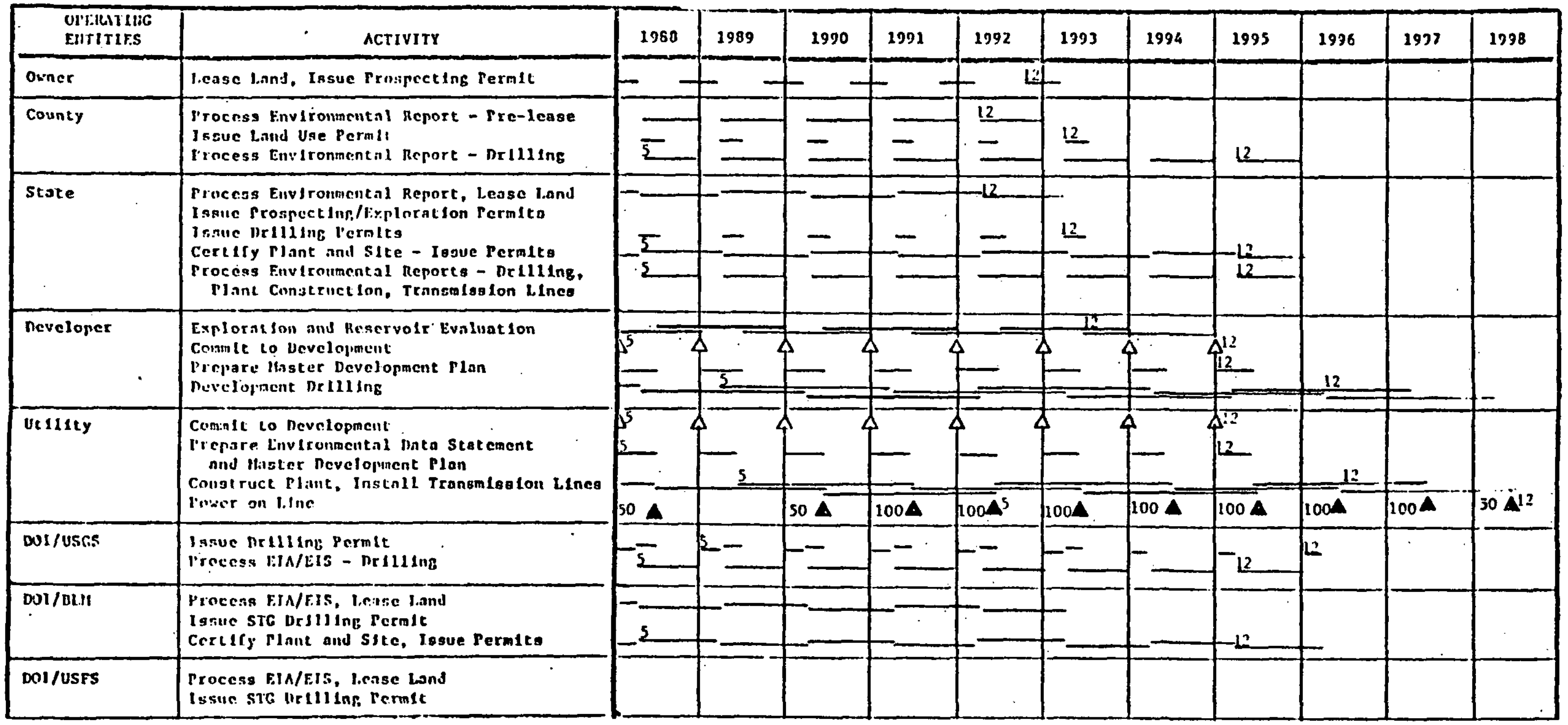


FIGURE 21-2 (CONCLUDED)

in the parallel experience at the Roosevelt Hot Springs and Brady sites, which are all expected to encounter similar problems in these technical areas of concern. No apparent environmental problems have been identified at this site nor has local opposition to development been expressed.

Economic Analysis. The projected economics of electrical generation of the Beowawe geothermal power prospect are presented in Table 21-I. The levelized busbar cost of flash-system conversion electricity[1] from this site is estimated to be 32.1 mills/kWh using currently available technology. Taking into account anticipated cost reductions from the RD&D program, the first commercial-scale plant at this site, postulated to come on line in 1983, is expected to have a levelized busbar energy cost of 29.1 mills/kWh (see second page of Table 21-I).

It is assumed that geothermal electric plants in this region will be competing primarily against coal-fueled steam plants for additions to baseload generating capacity. Under the assumptions of the National Energy Plan scenario for escalation of coal prices, the levelized busbar cost of electricity from coal-fueled steam plants is expected to be about 20.0 mills/kWh for plants coming on-line in 1985, rising to 20.6 mills/kWh for plants coming on-line in 1990.

[1] See Chapter 2 for details of the computer print-out and assumptions and data used in this analysis.

TABLE 21-I
ECONOMIC ANALYSIS: BEOWAWE, NEVADA
FLASH SYSTEM , 50 MW ELECTRIC PLANT
FIRST PLANT ON LINE DATE : 1983

TEMPERATURE IN CENTIGRADE DEGREES (BEST ESTIMATE) : 240
WELL DEPTH IN METERS : 1500
BRINE SALINITY : LOW
OVERLYING ROCK TYPE : HARD
THE WELL FLOW RATE IS NOT SPECIFIED : THE DEFAULT FLOW RATE USED (KGM./HR.) = 194299
THE COST PER PRODUCTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER PRODUCTION WELL ($) = 984251.6
THE COST PER INJECTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER INJECTION WELL ($) = 984251.6

PRODUCER FINANCIAL DATA

DEBT FRACTION :	0.30
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.20
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.10
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF PRODUCTION WELLS (YEARS) :	10.00
LIFE SPAN OF INJECTION WELLS (YEARS) :	10.00
LIFE SPAN OF PRODUCER PLANT (YEARS) :	20.00
START UP COST MULTIPLIER :	1.081

UTILITY FINANCIAL DATA

DEBT FRACTION :	0.50
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.12
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.0
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF UTILITY PLANT (YEARS) :	30.00
ULTIMATE CAPACITY FACTOR :	0.80
START UP COST MULTIPLIER :	1.038

* NUMBER OF WELLS , CAPITAL COSTBASIS AND O&M COSTS , AND REVENUE REQUIREMENTS WITHOUT ANY R&D IMPACTS *

CAPITAL COSTBASIS (1977 $M)

11 PRODUCTION WELLS :	13.032	
5 INJECTION WELLS :	5.924	
PRODUCER PLANT EXCLUDING WELLS :	4.026	
REPLACEMENT PRODUCTION WELLS :	11.130	
REPLACEMENT INJECTION WELLS :	5.059	
REPLACEMENT PLANT :	1.777	
TOTAL FOR PRODUCTION FIELD :		40.948
GENERATING PLANT :		23.281
TOTAL :		64.229

O&M COSTS (1977 $M/YR.)

PRODUCER		
GENERAL :	0.366	
WELL :	0.157	
DEEP WELL PUMP :	0.0	
SPENT BRINE TREATMENT :	0.0	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.546
UTILITY		
GENERAL :	0.679	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.679

** REVENUE REQUIREMENTS **

PRODUCER :	25.309 MILLS/KWHR
UTILITY :	6.774 MILLS/KWHR
* TOTAL :	32.083 MILLS/KWHR *

TABLE 21-I (CONTINUED)

* R&D IMPACTS FOR PLANT NO. 1 - ON LINE DATE : 1983 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
CAPITAL COST PER PRODUCTION WELL	-5.00	-0.7472
CAPITAL COST PER INJECTION WELL	-5.00	-0.3396

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 22.312 MILLS/KWHR
UTILITY : 6.774 MILLS/KWHR
* TOTAL : 29.086 MILLS/KWHR *

* SENSITIVITY OF COST OF ELECTRICITY (FROM PLANT NO. 1 , R&D IMPACTS INCLUDED) *

RESOURCE & OPERATING PARAMETERS	MILLS/KWHR
HIGH RESOURCE TEMPERATURE ESTIMATE (280 DEGREES CENTIGRADE)	20.935
LOW RESOURCE TEMPERATURE ESTIMATE (165 DEGREES CENTIGRADE)	93.815
HIGH CAPACITY FACTOR VALUE : 0.85	27.375
LOW CAPACITY FACTOR VALUE : 0.60	38.781
EXPENSING OF INTANGIBLE DRILLING COSTS (70.0% OF WELL COSTS EXPENSED)	25.672
DEPLETION ALLOWANCE (22.0% OF GROSS INCOME)	24.703
INVESTMENT TAX CREDIT (26.2% GROSS, 15.0% EFFECTIVE)	27.440

* R&D IMPACTS FOR PLANT NO. 2 - ON LINE DATE : 1986 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-12.00	-1.7932
CAPITAL COST PER INJECTION WELL	-12.00	-0.8151
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0581
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0220
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0689
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0266
LIFE SPAN OF PRODUCTION WELLS	20.00	-1.0902
LIFE SPAN OF INJECTION WELLS	100.00	-1.5120
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.1971

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 19.484 MILLS/KWHR
UTILITY : 6.537 MILLS/KWHR
* TOTAL : 26.021 MILLS/KWHR *

Beowawe, NV

TABLE 21-I (CONCLUDED)

* R&D IMPACTS FOR PLANT NO. 3 - ON LINE DATE : 1988 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-12.00	-1.7932
CAPITAL COST PER INJECTION WELL	-12.00	-0.8151
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0561
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0220
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0689
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0266
LIFE SPAN OF PRODUCTION WELLS	20.00	-1.1127
LIFE SPAN OF INJECTION WELLS	100.00	-1.5321
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.1971

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 19.448 MILLS/KWHR
UTILITY : 6.537 MILLS/KWHR
* TOTAL : 25.985 MILLS/KWHR *

* R&D IMPACTS FOR PLANT NO. 4 - ON LINE DATE : 1990 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-20.00	-2.9687
CAPITAL COST PER INJECTION WELL	-20.00	-1.3585
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0561
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0220
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0689
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0266
LIFE SPAN OF PRODUCTION WELLS	20.00	-1.1127
LIFE SPAN OF INJECTION WELLS	100.00	-1.5321
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-1.1971

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 17.985 MILLS/KWHR
UTILITY : 6.537 MILLS/KWHR
* TOTAL : 24.522 MILLS/KWHR *

Brawley, NV

The costs of electricity (with RD&D benefits) at this prospect are therefore not competitive without the advantage of further incentives. The sensitivity analysis for Plant 1 shows that expensing intangible drilling costs would reduce the levelized busbar cost by about 3.4 mills/kWh, that a 22 percent depletion allowance would reduce costs by at most 4.4 mills/kWh, and that an increased investment tax credit to 15 percent effective would reduce costs by about 1.7 mills/kWh. Thus, the use of all three of these incentives would be required to render this site roughly competitive on the basis of cost.

Subsequent Plants

Beowawe Plant 2, another 50-MWe plant, is postulated to go on line in 1986. However, with the three-year lead time necessary to incorporate design improvements, little prior operating experience will be available from the 1983 plants to benefit Plant 2.

As shown in the concluding pages of Table 21-I, continuing RD&D impacts, as designated, result in further decreases in cost of electricity. Subsequent plants in 1986, 1988 and 1990 are expected to have costs of 26.0, 26.0, and 24.5 mills/kWh, respectively. Even in 1990, the site would require special tax incentives to place it in a competitive economic position.

STEAMBOAT SPRINGS, NEVADA

Postulated Development Scenario

PLANT NUMBER	INSTALLED CAPACITY (MWe)	PLANT ON-LINE DATE
1	50	1985
2	50	1988
3	100	1990
SUBSEQUENT PLANTS	--	--
TOTAL	200	to 1990

Estimates of Resource Characteristics

RESOURCE CHARACTERISTIC	ESTIMATE
Subsurface Fluid Temperature (°C)	Range: No data Best Estimate 210
Total Dissolved Solids (PPM)	2,500
Electric Energy Potential (MWe 30 Years)	208
Overlying Rock	Medium-Hard: Granite and Metamorphic Type, Volcanic
Depth to Top of Reservoir (Meters)	300
Land Status	
Total KGRA acres	8,914
Total Federal acres	4,450
Federal acres leased	1,548
Total State and private acres	7,366
State and private acres leased	

Development Status and Activity

Many shallow wells are tapping the Steamboat Springs resources for space heating in the Reno suburbs. No deep wells have been drilled. Companies involved at Steamboat Springs include Magma Power Company, Southern Union Production Company, Phillips Petroleum Company, and Gulf Oil Company.

Major Development Problems

No severe technological RD&D problems have been identified. Major developmental hurdles at this site appear to be the proof of the existence of a viable power-producing reservoir and the resolution of conflicts regarding how the land will be used. BLM, for example, is considering the development of housing units on the land.

Postulated Development Scenario: Status and Implications

First Commercial-Scale Plant: 50 MWe in 1985

Some commercial interest has been shown in this site. Development of a flashed steam plant is postulated at Steamboat Springs by 1985, according to the schedule shown in Figure 28-1. Figure 28-2 shows the scheduled activities of the principal participants in the development of the three postulated plants at the Steamboat Springs prospect. To obtain power on line in 1985, commitment to development of the site is required in 1980, and final design must be completed in 1981.

Development Problems. A likely attribute of this site is its shallow reservoir depth, with a thin rock cover. Wells should

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
BLM/Owner	Lease Land	Developer	ASSUMED COMPLETED										
BLM	Process EIA	CEQ											
Developer	Preliminary Geophysical Exploration												
BLM	Issue STG Drilling Permit	Developer											
USGS	Issue Drilling Permit	Developer											
County	Issue Use Permit	Developer											
Developer	Exploratory Drilling & Reservoir Evaluation												
Developer	Develop Utility Interest												
Developer & Utility	Feasibility Study												
Producer (Developer) & Utility	Financial Negotiations												
Producer	Site Selection												
Producer & Utility	Design												
Producer & Utility	Commitment to Development					Δ							
Producer & Utility	Prepare Master Development Plan	BLM, USGS											
Utility	Prepare Environmental Data Statement	BLM, FPC, State, County											
BLM, FPC, State, USGS	Certify Plant & Site, Issue Permits	Producer & Utility											
USGS	Process EIA (Drilling)	CEQ											
FPC, State PUC	Process EIA (Plant)	CEQ											
FPC, State PUC	Process EIA (Transmission Line)	CEQ											
Producer	Development Drilling												
Utility	Plant Construction												
Utility	Install Transmission Line (16km)												

FIGURE 28-1
DEVELOPMENT SCHEDULE FOR FIRST PLANT: STEAMBOAT SPRINGS, NEVADA

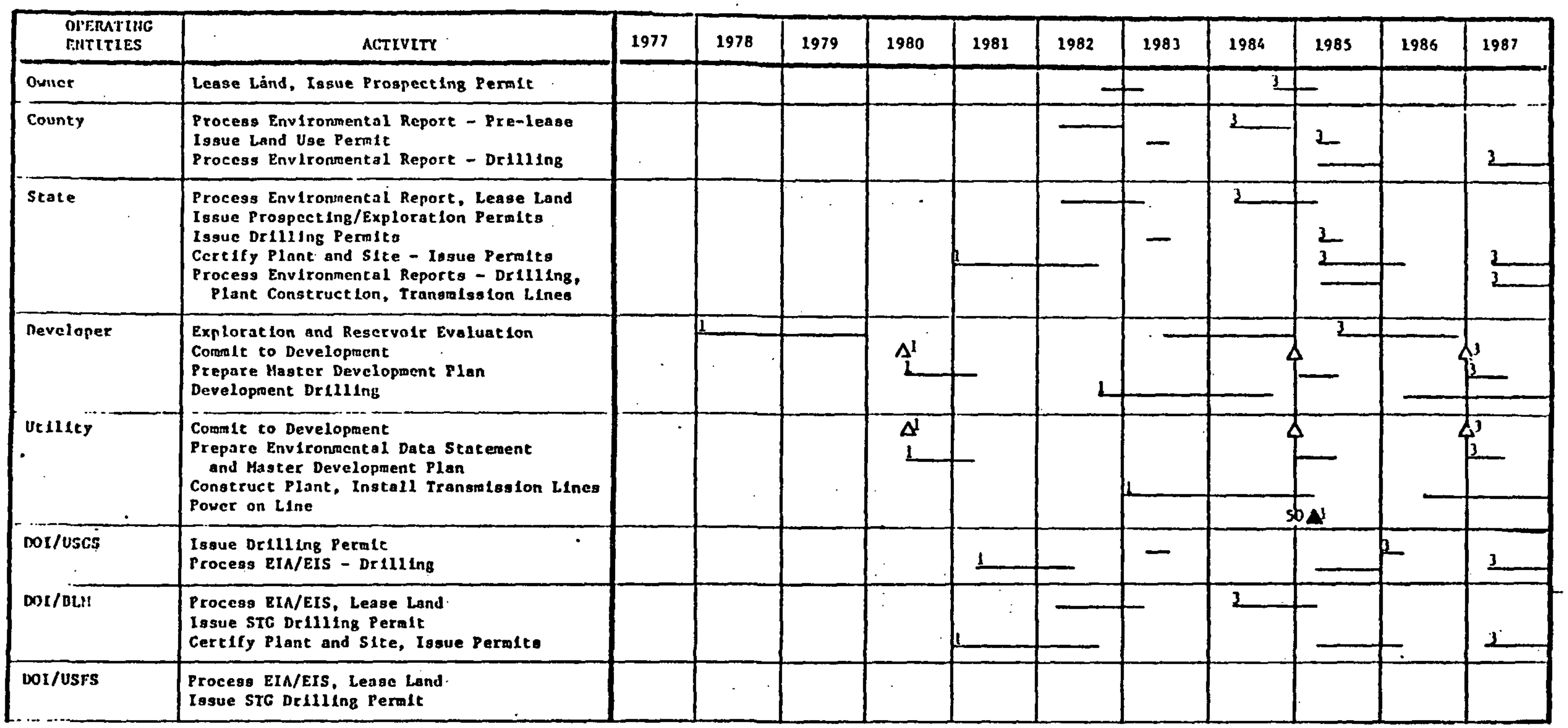


FIGURE 28-2
DEVELOPMENT SCHEDULE FOR ALL PLANTS: STEAMBOAT SPRINGS, NEVADA

OPERATING ENTITIES	ACTIVITY	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Owner	Lease Land, Issue Prospecting Permit											
County	Process Environmental Report - Pre-lease Issue Land Use Permit Process Environmental Report - Drilling											
State	Process Environmental Report, Lease Land Issue Prospecting/Exploration Permits Issue Drilling Permits Certify Plant and Site - Issue Permits Process Environmental Reports - Drilling, Plant Construction, Transmission Lines											
Developer	Exploration and Reservoir Evaluation Commit to Development Prepare Master Development Plan Development Drilling	3										
Utility	Commit to Development Prepare Environmental Data Statement and Master Development Plan Construct Plant, Install Transmission Lines Power on Line	3 50▲		100▲3								
DOI/USGS	Issue Drilling Permit Process EIA/EIS - Drilling											
DOI/BLM	Process EIA/EIS, Lease Land Issue STG Drilling Permit Certify Plant and Site, Issue Permits											
DOI/USFS	Process EIA/EIS, Lease Land Issue STG Drilling Permit											

FIGURE 28-2 (CONCLUDED)

therefore be relatively inexpensive. The major current problem is the uncertainty of the resource, i.e., whether or not there is a reservoir adequate to support power production.

There are indications that excessive calcite deposition has occurred in early production wells. This is a geochemical condition identified at other Nevada/Utah geothermal power prospects. Some test wells have shown evidence of a moderate-to-rapid decline in flow, related to a pressure drop at the bottom of the well plus possible fouling of the well. Prior related operational experience, especially with geochemistry, may be expected from the 1983 plants at Heber, Brady, Roosevelt Hot Springs, Valles Caldera, and Beowawe. However, these plants will not be in service early enough to influence the design of Steamboat Springs plant 1.

Economic Analysis. The projected economics of electrical generation at the Steamboat Springs geothermal power prospect are presented in Table 28-I. The levelized busbar cost of electricity[1] from a flash conversion system at this site is estimated to be 23.9 mills/kWh using currently available technology. Taking into account anticipated cost reductions from the RD&D program, the first commercial-scale plant at this site, postulated to come on line in 1985, is expected to have a levelized busbar energy cost of 22.3 mills/kWh.

[1]See Chapter 2 for a detailed description of the computer print-out and the assumptions and data used in this analysis.

TABLE 28-I
ECONOMIC ANALYSIS: STEAMBOAT SPRINGS, NEVADA
FLASH SYSTEM , 50 MW ELECTRIC PLANT
FIRST PLANT ON LINE DATE : 1985

TEMPERATURE IN CENTIGRADE DEGREES (BEST ESTIMATE) : 210
WELL DEPTH IN METERS : 800
BRINE SALINITY : LOW
OVERLYING ROCK TYPE : MEDIUM HARD
THE WELL FLOW RATE IS NOT SPECIFIED : THE DEFAULT FLOW RATE USED (KGM./HR.) = 212491
THE COST PER PRODUCTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER PRODUCTION WELL ($) = 328084.0
THE COST PER INJECTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER INJECTION WELL ($) = 328084.0

PRODUCER FINANCIAL DATA

DEBT FRACTION :	0.30
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.20
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.10
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF PRODUCTION WELLS (YEARS) :	10.00
LIFE SPAN OF INJECTION WELLS (YEARS) :	10.00
LIFE SPAN OF PRODUCER PLANT (YEARS) :	20.00
START UP COST MULTIPLIER :	1.081

UTILITY FINANCIAL DATA

DEBT FRACTION :	0.50
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.12
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.0
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF UTILITY PLANT (YEARS) :	30.00
ULTIMATE CAPACITY FACTOR :	0.80
START UP COST MULTIPLIER :	1.038

* NUMBER OF WELLS , CAPITAL COSTBASIS AND O&M COSTS , AND REVENUE REQUIREMENTS WITHOUT ANY R&D IMPACTS *

CAPITAL COSTBASIS (1977 $M)

16 PRODUCTION WELLS :	6.319	
7 INJECTION WELLS :	2.764	
PRODUCER PLANT EXCLUDING WELLS :	6.600	
REPLACEMENT PRODUCTION WELLS :	5.396	
REPLACEMENT INJECTION WELLS :	2.361	
REPLACEMENT PLANT :	2.912	
TOTAL FOR PRODUCTION FIELD :		26.352
GENERATING PLANT :		26.331
TOTAL :		52.683

O&M COSTS (1977 $M/YR.)

PRODUCER		
GENERAL :	0.271	
WELL :	0.075	
DEEP WELL PUMP :	0.0	
SPENT BRINE TREATMENT :	0.0	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.347
UTILITY		
GENERAL :	0.768	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		0.768

** REVENUE REQUIREMENTS **

PRODUCER : 16.272 MILLS/KWHR
UTILITY : 7.662 MILLS/KWHR
* TOTAL : 23.934 MILLS/KWHR *

TABLE 28-I (CONTINUED)

* R&D IMPACTS FOR PLANT NO. 1 -- ON LINE DATE : 1985 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
CAPITAL COST PER PRODUCTION WELL	-5.00	-0.3623
CAPITAL COST PER INJECTION WELL	-5.00	-0.1585

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 14.680 MILLS/KWHR
UTILITY : 7.662 MILLS/KWHR
* TOTAL : 22.342 MILLS/KWHR *

* SENSITIVITY OF COST OF ELECTRICITY (FROM PLANT NO. 1 , R&D IMPACTS INCLUDED) *

RESOURCE & OPERATING PARAMETERS	MILLS/KWHR
HIGH RESOURCE TEMPERATURE ESTIMATE (250 DEGREES CENTIGRADE)	15.375
LOW RESOURCE TEMPERATURE ESTIMATE (180 DEGREES CENTIGRADE)	39.545
HIGH CAPACITY FACTOR VALUE : 0.85	21.028
LOW CAPACITY FACTOR VALUE : 0.60	29.789
EXPENSING OF INTANGIBLE DRILLING COSTS (70.0% OF WELL COSTS EXPENSED)	20.737
DEPLETION ALLOWANCE (22.0% OF GROSS INCOME)	19.458
INVESTMENT TAX CREDIT (26.2% GROSS, 15.0% EFFECTIVE)	21.083

* R&D IMPACTS FOR PLANT NO. 2 -- ON LINE DATE : 1988 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-12.00	-0.8694
CAPITAL COST PER INJECTION WELL	-12.00	-0.3804
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0813
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0383
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0833
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0282
LIFE SPAN OF PRODUCTION WELLS	20.00	-0.5394
LIFE SPAN OF INJECTION WELLS	100.00	-0.7150
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-0.8397

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 13.224 MILLS/KWHR
UTILITY : 7.390 MILLS/KWHR
* TOTAL : 20.614 MILLS/KWHR *

Steamboat Springs, NV

TABLE 28-I (CONCLUDED)

* R&D IMPACTS FOR PLANT NO. 3 - ON LINE DATE : 1990 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-3.00	0.0
CAPITAL COST PER PRODUCTION WELL	-20.00	-1.4490
CAPITAL COST PER INJECTION WELL	-20.00	-0.6340
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0813
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0383
CAPITAL COST OF TURBINE GENERATOR	-3.00	-0.0833
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-10.00	-0.0282
LIFE SPAN OF PRODUCTION WELLS	20.00	-0.5394
LIFE SPAN OF INJECTION WELLS	100.00	-0.7150
START UP COST MULTIPLIERS	(PRODUCER: -4.16 , UTILITY: -2.12)	-0.8397

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 12.522 MILLS/KWHR
UTILITY : 7.390 MILLS/KWHR
* TOTAL : 19.912 MILLS/KWHR *

Steamboat Springs, NV

It is assumed that geothermal electric plants in this region will be competing primarily against coal-fired steam power plants for baseload generating capacity additions. Under assumptions of the National Energy Plan scenario for escalation of coal prices, the levelized busbar cost of electricity from these sources is expected to be about 20.0 mills/kWh for plants coming on-line in 1985, rising to 20.6 mills/kWh for plants coming on-line in 1990.

The costs of electricity (with RD&D benefits) at this prospect therefore appear marginally competitive without the advantages of further incentives. The sensitivity analysis for Plant 1 shows that expensing intangible drilling costs would reduce the levelized busbar cost by about 1.6 mills/kWh, that a 22 percent depletion allowance would reduce costs by at most 2.9 mills/kWh and that an increased investment tax credit to 15 percent effective would reduce costs by about 1.3 mills/kWh. Thus, the use of at least one of these incentives and certainly no more than two would appear to bring the costs of this plant into a position competitive with coal.

Subsequent Plants

The 50-MWe Steamboat Springs Plant 2 is projected to go on line in 1988. The design of this plant should benefit from operating experience at the 1983 flash conversion plants at Brady Hot Springs, Roosevelt Hot Springs, and perhaps from Valles Caldera and Salton Sea and Brawley (should the latter two be flash-type plants).

Incorporating advanced RD&D findings and their postulated impacts into Plant 2 development (Table 28-I) produces an estimated cost of electricity of 20.6 mills/kWh.

The third and final plant designated for development at Steamboat Springs, 100-MWe capacity in 1990, is projected to produce electricity at a favorable busbar cost of 19.9 mills/kWh without Federal subsidies.

LEACH, NEVADA

Postulated Development Scenario

PLANT NUMBER	INSTALLED CAPACITY (MWe)	PLANT ON-LINE DATE
1	50	1987
2	50	1990
SUBSEQUENT PLANTS	1400	1991-2002
TOTAL	1500	to 2002

Estimate of Resource Characteristics

RESOURCE CHARACTERISTIC		ESTIMATE
Subsurface Fluid Temperature (°C)	Range: Best Estimate:	170-200 170
Total Dissolved Solids (PPM)		No data
Electric Energy Potential (MWe 30 Years)		1500
Overlying Rock		No data
Depth to Top of Reservoir (Meters)		No data
Land Status		
Total KGRA acres		12,797
Total Federal acres		12,246
Federal Acres leased		12,246
Total State and private acres		551
State and private acres leased		No data

Development Status and Activity

Considerable surface exploration was underway by June, 1976. Industry involvement in site development may include Sun Oil Company and Magma Power Company.

Major Development Problems

There are two significant problems at the Leach site: whether or not a viable, developable reservoir exists and whether or not the unfavorable economics can be improved.

Postulated Development Scenario: Status and Implications

First Commercial-Scale Plant: 50 MWe in 1987

A developer and/or plant operator has not yet been identified for this prospect (Sun Oil and Magma Power are possibilities). As shown in Figure 25-1, the first plant is expected to go on line in 1987. This requires that the existence of a commercial reservoir must be established by 1982. Figure 25-2 shows the scheduled activities of principal participants in the development of the two plants postulated at the Leach prospect. A binary conversion system is likely to be preferred at this site.

Development Problems. It is believed that no significant technological problems will remain by the time the final design for the plant must be completed. A little prior operating experience is expected to be available to benefit the development at Leach: Heber 1 (along with Salton Sea 1 and Brawley 1, if binary), will just be operational; Cove Fort-Sulphurdale and East Mesa will be in construction; and progress in parallel should be shared with Alvord 1, Bruneau-Grandview 1, and Cove Fort-Sulphurdale 2. The work in development and testing of organic turbines may have been conducted

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
BLM	Process Environmental Reports	CEQ	ASSUMED COMPLETED										
BLM	Lease Land	Developer											
	Issue Drilling Permits	Developer											
Developer	Preliminary Geophysical Exploration												
Developer	Exploratory Drilling and Reservoir Evaluation												
Developer	Develop Utility Interest												
Developer and Utility	Feasibility Study												
Producer (Developer) and Utility	Financial Negotiations												
Producer	Site Selection												
Producer and Utility	Commitment to Development							Δ					
Producer and Utility	Design												
Producer and Utility	Prepare Master Development Plan	BLM, USGS											
Utility	Prepare Environmental Data Statement	BLM, FPC, State, County											
BLM, FPC, State, USGS	Certify Plant and Site, Issue Permits	Producer and Utility											
USGS	Process EIA/EIS (Drilling)	CEQ											
FPC	Process EIA/EIS (Plant)	CEQ											
FPC	Process EIA/EIS (Transmission Line)	CEQ											
Producer	Development Drilling												
Utility	Plant Construction												
Utility	Install Transmission Line												

FIGURE 25-1
DEVELOPMENT SCHEDULE FOR FIRST PLANT: LEACH, NEVADA
(FEDERAL LAND)

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Owner	Lease Land, Issue Prospecting Permit											
County	Process Environmental Report - Pre-lease Issue Land Use Permit Process Environmental Report - Drilling											
State	Process Environmental Report, Lease Land Issue Prospecting/Exploration Permits Issue Drilling Permits Certify Plant and Site - Issue Permits Process Environmental Reports - Drilling, Plant Construction, Transmission Lines											
Developer	Exploration and Reservoir Evaluation Commit to Development Prepare Master Development Plan Development Drilling											
Utility	Commit to Development Prepare Environmental Data Statement and Master Development Plan Construct Plant, Install Transmission Lines Power on Line											50
DOI/USGS	Issue Drilling Permit Process EIA/EIS - Drilling											
DOI/BLM	Process EIA/EIS, Lease Land Issue STG Drilling Permit Certify Plant and Site, Issue Permits											
DOI/USFS	Process EIA/EIS, Lease Land Issue STG Drilling Permit											

FIGURE 25-2
DEVELOPMENT SCHEDULE FOR ALL PLANTS: LEACH, NEVADA

OPERATING ENTITIES	ACTIVITY	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Owner	Lease Land, Issue Prospecting Permit											
County	Process Environmental Report - Pre-lease											
	Issue Land Use Permit											
	Process Environmental Report - Drilling											
State	Process Environmental Report, Lease Land											
	Issue Prospecting/Exploration Permits											
	Issue Drilling Permits											
	Certify Plant and Site - Issue Permits											
	Process Environmental Reports - Drilling, Plant Construction, Transmission Lines											
Developer	Exploration and Reservoir Evaluation											
	Commit to Development											
	Prepare Master Development Plan											
	Development Drilling											
Utility	Commit to Development											
	Prepare Environmental Data Statement and Master Development Plan											
	Construct Plant, Install Transmission Lines											
	Power on Line											
DOI/USGS	Issue Drilling Permit											
	Process EIA/EIS - Drilling											
DOI/BLM	Process EIA/EIS, Lease Land											
	Issue STG Drilling Permit											
	Certify Plant and Site, Issue Permits											
DOI/USFS	Process EIA/EIS, Lease Land											
	Issue STG Drilling Permit											

FIGURE 25-2 (CONTINUED)

OPERATING ENTITIES	ACTIVITY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Owner	Lease Land, Issue Prospecting Permit											
County	Process Environmental Report - Pre-lease Issue Land Use Permit Process Environmental Report - Drilling											
State	Process Environmental Report, Lease Land Issue Prospecting/Exploration Permits Issue Drilling Permits Certify Plant and Site - Issue Permits Process Environmental Reports - Drilling, Plant Construction, Transmission Lines											
Developer	Exploration and Reservoir Evaluation Commit to Development Prepare Master Development Plan Development Drilling	13										
Utility	Commit to Development Prepare Environmental Data Statement and Master Development Plan Construct Plant, Install Transmission Lines Power on Line	13 100▲	100▲	100▲13								
DOI/USGS	Issue Drilling Permit Process EIA/EIS - Drilling											
DOI/BLM	Process EIA/EIS, Lease Land Issue STG Drilling Permit Certify Plant and Site, Issue Permits											
DOI/USFS	Process EIA/EIS, Lease Land Issue STG Drilling Permit											

FIGURE 25-2 (CONCLUDED)

in the 10-MWe pilot plant at Niland. One year prior to design freeze on the Leach plant, deep-well pumps of improved reliability and durability are expected to be available (1.5-year expected life versus the current less-than-6-month life).

Economic Analysis. The projected economics of electrical generation at the Leach, Nevada, geothermal power prospect are presented in Table 25-I. The levelized busbar cost of electricity[1] by binary conversion from this site is estimated to be 109 mills/kWh using currently available (baseline) technology. Taking into account anticipated cost reductions from the RD&D program, the first commercial-scale plant at this site, postulated to come on line in 1987, is expected to have a levelized busbar energy cost of 75 mills/kWh.

It is assumed that geothermal electric plants in this region will be competing primarily against coal-fueled steam plants for baseload generating capacity addition. Under assumptions of the National Energy Plan scenario for escalation of coal prices, the levelized busbar cost of electricity from these sources is expected to be about 20.0 mills/kWh for plants coming on-line in 1985, rising to 20.6 mills/kWh for plants coming on-line in 1990.

The cost of electricity (with RD&D benefits) at this prospect is therefore definitely not competitive without the advantage of further

[1] See Chapter 2 for a detailed description of the computer print-out and the assumptions and data used in this analysis.

TABLE 25-1
ECONOMIC ANALYSIS: LEACH, NEVADA
BINARY SYSTEM , 50 MW ELECTRIC PLANT
FIRST PLANT ON LINE DATE : 1987

TEMPERATURE IN CENTIGRADE DEGREES (BEST ESTIMATE) : 170
WELL DEPTH IN METERS : 2500
BRINE SALINITY : LOW
OVERLYING ROCK TYPE : MEDIUM HARD
THE WELL FLOW RATE IS NOT SPECIFIED : THE DEFAULT FLOW RATE USED (KGM./HR.) = 268208
THE COST PER PRODUCTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER PRODUCTION WELL ($) =2138286.0
THE COST PER INJECTION WELL IS NOT SPECIFIED : THE DEFAULT COST PER INJECTION WELL ($) =1425524.0

PRODUCER FINANCIAL DATA

DEBT FRACTION :	0.30
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.20
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.10
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF PRODUCTION WELLS (YEARS) :	10.00
LIFE SPAN OF INJECTION WELLS (YEARS) :	10.00
LIFE SPAN OF PRODUCER PLANT (YEARS) :	20.00
START UP COST MULTIPLIER :	1.036

UTILITY FINANCIAL DATA

DEBT FRACTION :	0.50
ANNUAL INTEREST RATE ON DEBT (FRACTION) :	0.08
REQUIRED RATE OF RETURN ON EQUITY (FRACTION) :	0.12
PROPERTY TAX RATE (FRACTION) :	0.01
REVENUE TAX RATE OR ROYALTY (FRACTION) :	0.0
EFFECTIVE TOTAL INCOME TAX RATE (FRACTION) :	0.50
EFFECTIVE INVESTMENT TAX CREDIT (FRACTION) :	0.04
ESCALATION FACTOR FOR O&M COSTS :	0.05
ESCALATION FACTOR FOR ENERGY COSTS :	0.05
ESCALATION FACTOR FOR CAPITAL COSTS :	0.05
LIFE SPAN OF UTILITY PLANT (YEARS) :	30.00
ULTIMATE CAPACITY FACTOR :	0.80
START UP COST MULTIPLIER :	1.016

* NUMBER OF WELLS , CAPITAL COSTBASIS AND O&M COSTS , AND REVENUE REQUIREMENTS WITHOUT ANY R&D IMPACTS *

CAPITAL COSTBASIS (1977 $M)

24 PRODUCTION WELLS :	61.774	
10 INJECTION WELLS :	17.159	
PRODUCER PLANT EXCLUDING WELLS :	9.501	
REPLACEMENT PRODUCTION WELLS :	52.756	
REPLACEMENT INJECTION WELLS :	14.655	
REPLACEMENT PLANT :	4.192	
TOTAL FOR PRODUCTION FIELD :		160.038
GENERATING PLANT :		36.674
TOTAL :		196.712

O&M COSTS (1977 $M/YR.)

PRODUCER		
GENERAL :	1.485	
WELL :	0.656	
DEEP WELL PUMP :	0.850	
SPENT BRINE TREATMENT :	0.0	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		2.991
UTILITY		
GENERAL :	1.319	
CHEMICAL & MECHANICAL CLEANING :	0.0	
TOTAL :		1.319

** REVENUE REQUIREMENTS **

PRODUCER : 97.612 MILLS/KWHR
UTILITY : 11.167 MILLS/KWHR
* TOTAL : 108.779 MILLS/KWHR *

Leach, NV

TABLE 25-I (CONTINUED)

* R&D IMPACTS FOR PLANT NO. 1 - ON LINE DATE : 1987 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-22.00	-14.1423
CAPITAL COST PER PRODUCTION WELL	-12.00	-8.1459
CAPITAL COST PER INJECTION WELL	-12.00	-2.2628
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0949
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0965
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-50.00	-0.6446
CAPITAL COST OF CONDENSER & HEAT REJECTION EQUIPMENT	-20.00	-0.6630
PRODUCER DEEP WELL PUMP O&M COST FACTOR (BINARY SYSTEM , TEMP <260 C)	-67.00	-1.8711
LIFE SPAN OF PRODUCTION WELLS	20.00	-5.0543
LIFE SPAN OF INJECTION WELLS	100.00	-4.2531

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 65.432 MILLS/KWHR
UTILITY : 9.859 MILLS/KWHR
* TOTAL : 75.291 MILLS/KWHR *

* SENSITIVITY OF COST OF ELECTRICITY (FROM PLANT NO. 1 , R&D IMPACTS INCLUDED) *

RESOURCE & OPERATING PARAMETERS	MILLS/KWHR
HIGH RESOURCE TEMPERATURE ESTIMATE (200 DEGREES CENTIGRADE)	46.426
LOW RESOURCE TEMPERATURE ESTIMATE (140 DEGREES CENTIGRADE)	151.133
HIGH CAPACITY FACTOR VALUE : 0.85	70.862
LOW CAPACITY FACTOR VALUE : 0.60	100.388
EXPENSING OF INTANGIBLE DRILLING COSTS (70.0% OF WELL COSTS EXPENSED)	64.997
DEPLETION ALLOWANCE (22.0% OF GROSS INCOME)	62.438
INVESTMENT TAX CREDIT (26.2% GROSS, 15.0% EFFECTIVE)	71.103

Leach, NV

TABLE 25-I (CONCLUDED)

* R&D IMPACTS FOR PLANT NO. 2 - ON LINE DATE : 1990 *

R&D COMPONENT	ANTICIPATED CHANGE (%)	CHANGE IN REVENUE REQUIREMENTS (MILLS/KWHR)
NUMBER OF PRODUCTION WELLS	-22.00	-14.1423
CAPITAL COST PER PRODUCTION WELL	-20.00	-13.5766
CAPITAL COST PER INJECTION WELL	-20.00	-3.7713
CAPITAL COST OF GATHERING SYSTEM	-10.00	-0.0949
CAPITAL COST OF DISTRIBUTION SYSTEM	-10.00	-0.0965
CAPITAL COST OF PROCESS MECHANICAL (UTILITY)	-50.00	-0.6446
CAPITAL COST OF CONDENSER & HEAT REJECTION EQUIPMENT	-20.00	-0.6630
PRODUCER DEEP WELL PUMP O&M COST FACTOR (BINARY SYSTEM , TEMP <260 C)	-67.00	-1.8711
LIFE SPAN OF PRODUCTION WELLS	20.00	-5.0543
LIFE SPAN OF INJECTION WELLS	100.00	-4.2531

** REVENUE REQUIREMENTS WITH ALL THE R&D IMPACTS INCLUDED. **

PRODUCER : 60.285 MILLS/KWHR
UTILITY : 9.859 MILLS/KWHR
* TOTAL : 70.144 MILLS/KWHR *

incentives. The sensitivity analysis for Plant 1 shows that expensing intangible drilling costs would reduce the levelized busbar cost by about 10.3 mills/kWh, that a 22 percent depletion allowance would reduce costs by at most 12.9 mills/kWh and that an increased investment tax credit to 15 percent effective would reduce costs by about 4.2 mills/kWh. Thus, the use of all three plus further incentives would be required to render this plant roughly competitive on the basis of cost. Within limits, changes in the levels of the depletion allowance or tax credit would produce proportional cost changes and such changes could be made to achieve a desired level of Federal incentive. However, very large incentives would be required to make this site cost-competitive.

Subsequent Plants

Plant 2 at the Leach site, an additional 50-MWe capacity, is scheduled to come on line in 1990. At that late date, RD&D-related technological improvements available in 1987 should bring the economics down to 70 mills/kWh, still highly noncompetitive with power from coal-fueled plants.