GL03079

PLAN OF OPERATION,

DEVELOPMENT

Lease Nos. CA 966 and CA 1903
Sec. 25, T15S, R16E; Secs. 19,20,28,29 and 30
T15S, R17E, SB B&M

East Mesa, Imperial County, California

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Proposal to commence operations for initial development of the geothermal resource, including five production wells and three injection wells, related pipelines, access roads, testing and other surface facilities necessary to initiate production of electricity at a 10 Mw power plant.

Estimated Starting Date: One week from date of approval

Estimated Completion Date: January, 1979

REPUBLIC GEOTHERMAL, INC.

PLAN OF OPERATION, DEVELOPMENT
10 Mw POWER PLANT

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REPUBLIC GEOTHERMAL, INC.

PLAN OF OPERATION, DEVELOPMENT
UNITED STATES GEOTHERMAL LEASE NOS. CA 966 and CA 1903
EAST MESA, IMPERIAL COUNTY, CALIFORNIA

A. PROPOSED PLAN OF OPERATION

Republic Geothermal, Inc. proposes herein to commence the initial stages of geothermal development operations on Leases CA 966 and CA 1903. This Plan of Operation, Development is submitted in accordance with 30 CFR 270.34 and draft GRO Order No. 5, and covers phases of additional geothermal well drilling and facility construction necessary to initiate production of electricity at a 10 Mw power plant.

Five production wells (Nos. 16-30, 56-30 and 16-29, existing; Nos. 36-30 and 76-30, proposed) and three injection wells (No. 18-28, existing; Nos. 52-29 and 56-29, proposed) are planned to be dedicated to the proposed power plant, as well as related pipelines, access roads, and well testing and production facilities. Three alternative power plant sites are included in this Plan of Operation to provide a perspective of the overall development. The site selection and details of the power plant operation will be contingent upon evaluation and approval of Republic's Plan of Utilization, which will be submitted to the Supervisor in accordance with proposed amendments to 30 CFR, Section 270 and 43 CFR, Part 3208.

Proposed well locations and access roads have been previously evaluated and approved in Republic's Plans of Operation, Exploration (USGS-AGS Environmental Analysis #12 and Environmental Analysis #29) with the exception of the location pad for Well No. 56-29 and the proposed north-south access road from alternative plant site A to the existing east-west access road of the five production wells. Pipelines from production wells to the selected power plant site and from the power plant site to injection wells will be constructed along access roads with horizontal expansion loops.

Consistent with draft GRO Order No. 5, the purpose of this Plan and the intent of Republic Geothermal, Inc. is to assure orderly and timely development of the resource, to maximize the productivity of the resource and to minimize adverse environmental impacts. Also consistent with draft GRO Order No. 5 and proposed amendments to 30 CFR 270 and 43 CFR 3208, Republic is submitting this Plan of Operation, Development for evaluation of proposed development necessary to allow initiation of commercial production; a Plan of Operation, Injection for evaluation of proposed subsurface injection; and a Plan of Utilization for evaluation of the alternative power plant sites, electric transmission lines, and proposed method of utilizing the resource.

B. DETAILS OF PROPOSED PLAN

1. Location and Placement of Proposed Operations

a. Maps

Attached hereto and made a part hereof as Exhibit A is our Drawing No. 199-10, East Mesa Geothermal Project Vicinity Map, which shows the topography, drainage patterns, cultural features and existing roads and wells. The Vicinity Map also shows existing and proposed transmission lines for informational purposes.

Attached hereto and made a part hereof as Exhibit B is our Drawing No. 199-11, East Mesa Geothermal Project Development Plan-10 Mw Power Plant, which shows the proposed location and spacing of wells, existing and proposed access roads and alternative power plant sites. Pipelines will be located along the existing and proposed access roads.

b. Justification for Proposed Location and Spacing of Wells

The location of the eight wells (five producers, three injectors) devoted to the proposed 10 Mw power plant must be viewed in relation to the overall resource development plan for justification. Figure 1 shows conceptual well locations for a 48 Mw net project having 19 interior producers and 9 peripheral injectors. Sufficient well control and geophysical evidence exists to indicate that this is a reasonable minimum interpretation of the ultimate project scope. Wells devoted to the 10 Mw plant can be seen to be an integral part of the overall plan.

Peripheral injection (Figure 1) into the interval 2000+ to 5000+ feet and production from a central group of producers completed

CONCEPTUAL WELL LOCATION PLAN
FUTURE 48 NET MW PROJECT

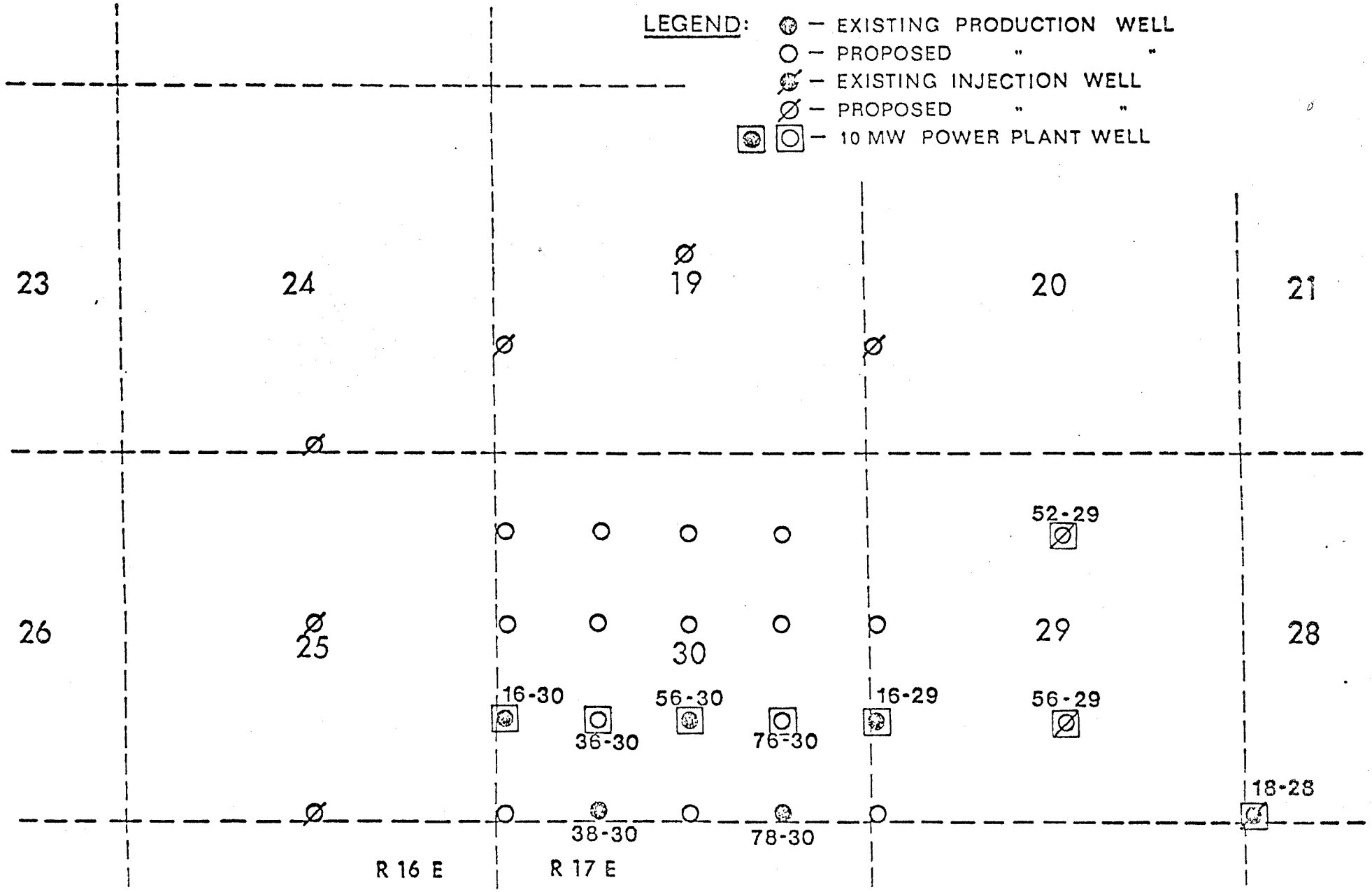


Figure 1

in the interval 5500± to 7500± feet is currently considered to be the most advantageous manner in which to develop the East Mesa reservoir. Such a pattern maximizes the time and path of travel of the cooler reinjected waters between the injectors and producers. The longer the reinjected water is in contact with the hot reservoir rock, the hotter it will be when it arrives back at the producers. Thus, the life of the resource will be much greater with such a pattern relative to that which would be expected with any interior reinjection pattern alternative.

Injection into the shallower sands rather than directly into the productive reservoir is also advantageous economically and environmentally. Because the shallower sands have a much higher permeability than those of the reservoir, it should be possible to inject the water from two producers into a single injector using a low surface pressure. Thus, well costs, energy costs (pump power), and surface usage will be minimized relative to a deep interior reinjection pattern.

Good vertical communication below 2000± feet is the key to the success of such a shallow peripheral reinjection plan. Preliminary reservoir simulation work shows that with vertical communication, pressure can be maintained in the interior producing area when aided by a minor amount of aquifer influx. The required influx need only be enough to replace evaporative losses at the plant, and will certainly exist during operation of the 10 Mw plant by itself. When the larger plant(s) comes on line, the natural influx may or may not have to be supplemented, and that determination will require several years of full-scale production experience.

Substantial evidence exists that good vertical communication and hot water influx from depth are present at East Mesa, as is detailed in

later sections. The convective nature of the temperature profiles below 2000± feet indicates both vertical communication and water influx. Hot water influx from below the producing interval is also indicated by the silica and alkalai chemical equilibrium temperatures of the produced fluids. Well logs and geologic correlations show essentially sand-on-sand contacts throughout the vertical sequence below 2000± feet. Finally, pressure interference testing by Lawrence Berkeley Laboratories shows that USBR Well Nos. 6-1 and 6-2, and USBR Well No. 31-1 and Republic Well No. 38-30 communicate, even though the completion intervals of each well pair do not overlap vertically.

The foregoing discussion is intended to justify the well location concept for overall development and, indirectly, for the 10 Mw plant. Similarly, well spacing must also be viewed in the context of an overall plan. An acceptable spacing of 40-acres per well as shown on Figure 1 was established with a reservoir simulation study (discussed in more detail in a later section). For this study, the most conservative conditions of "no influx" and "no vertical communication" were assumed. Under these conditions, interior five-spot pattern reinjection may be required for pressure maintenance.

Results of the 40-acre spacing five-spot simulations show that pressure can easily be maintained, but that some produced fluid temperature decline will be experienced after 12± years. This is illustrated in Figure 2. While this amount of temperature decline is tolerable and easily compensated for by a few make-up wells, closer spacings which were investigated (i.e., 20-acres and 10-acres per well), resulted in earlier breakthroughs and more precipitous temperature declines. This would require a substantially greater number

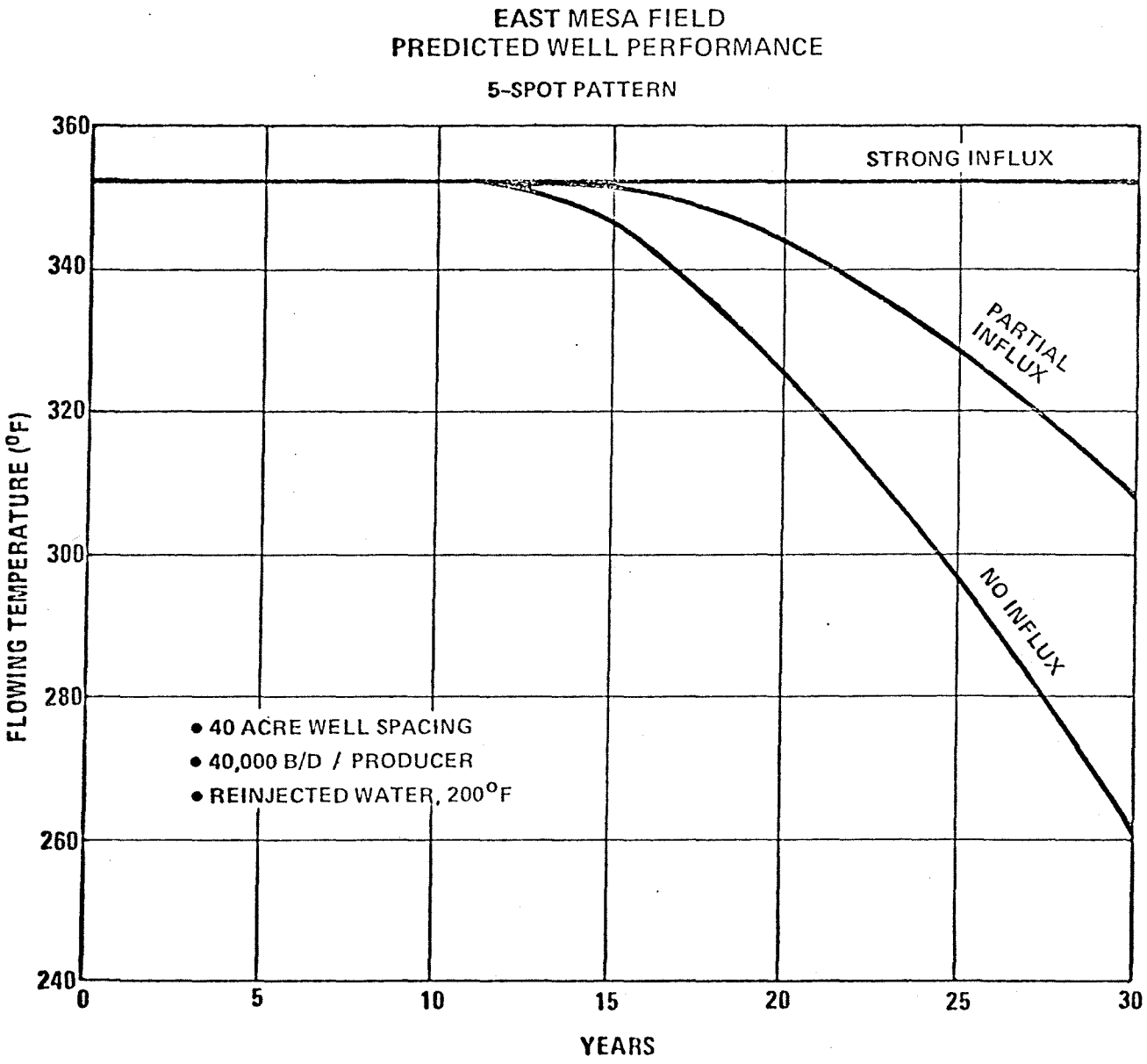

EAST MESA FIELD
PREDICTED WELL PERFORMANCE
5-SPOT PATTERN
STRONG INFLUX
PARTIAL INFLUX
NO INFLUX
• 40 ACRE WELL SPACING
• 40,000 B/D / PRODUCER
• REINJECTED WATER, 200°F
FLOWING TEMPERATURE (°F)
360
340
320
300
280
260
240
0
5
10
15
20
25
30
YEARS

Figure 2

of make-up wells to sustain a 25- to 30-year plant life. Thus, 40-acres per well spacing has been established as an acceptable spacing in the event that an interior five-spot reinjection pattern must be resorted to in order to maintain pressure.

It should be emphasized that five-spot reinjection is not the expected mode of operation. Evidence thus far available indicates that the peripheral injection scheme discussed above will be successful, and that production well spacing will be of little importance to efficient development of the resource.

In addition, topographic features, drainage patterns and current land uses were considered in well spacing. The topography at East Mesa is essentially level. Surface water is limited to one short section of the East Highline Canal, and the leases are devoid of obvious stream channels. Land in the area of the proposed development is open space desert. The dominant plant species is that of the creosote bush (Larrea divaricata). Immediately southwest of the southwestern corner of the leasehold is an orange orchard which occupies less than one section of land.

None of the above factors presents an environmental concern which would determine or limit the location of wells or roads within the boundaries of the leases. Thus the wells are spaced at 40-acre intervals for maximum efficiency and utilization of the resource based on the data briefly discussed earlier and described in more detail in a later section.

2. Discussion of Proposed Operations

a. Continuation of previously approved testing of existing Well Nos. 16-29, 56-30 and 16-30; involving data analysis, sustained production testing and workovers as necessary.

b. Continuation of previously approved testing of existing Well No. 18-28; involving data analysis, sustained injection testing and workovers as necessary.

c. Construction of four additional drilling location sites: Well Nos. 36-30, 76-30, 52-29 and 56-29. All well locations except Well No. 56-29 have been previously evaluated under Republic's Plans of Operation, Exploration approved as effective 9/12/75 (USGS-AGS Environmental Analysis #12) and 12/15/75 (USGS-AGS Environmental Analysis #29).

d. Drilling and completion of Well Nos. 36-30 and 76-30 as potential production wells, and Well Nos. 52-29 and 56-29 as potential injection wells; including clean-out flows and initial testing to the storage basin.

e. After analyzation of the log and test data, conduct workovers of these additional wells if required.

f. Continuation of initial testing of the additional wells, data analysis and workovers until wells demonstrate satisfactory commercial production or injection potential.

g. Construction of production test facilities for the additional wells drilled as potential producers, including a waste fluid disposal pipeline to an approved temporary waste disposal or injection well.

h. Placement of these additional wells on sustained production testing.

i. If any well drilled as a production well does not demonstrate satisfactory commercial potential, conduct workovers of well and convert to temporary waste disposal or injection well.

j. Construction of injection test facilities for those additional wells drilled as injectors or any approved converted well, including the connection of a waste disposal pipeline from any of the other wells.

k. Placement of injection wells on sustained injection testing and utilization of converted wells for either temporary waste disposal or injection, as approved.

l. If any well drilled as an injection well indicates commercial potential, conduct workovers and convert to a production well. Construct production test facilities, including pipeline, and place on sustained production testing. If this event occurs a new Plan of Operation, Development will be prepared based on the new data.

Republic recognizes that prior to commencing any of the above-mentioned operations, specific details must be submitted to the Area Geothermal Supervisor and explicit approval obtained. Republic also recognizes that prior to commencing injection at any of the proposed wells, a Plan of Operation, Injection must be approved. Proposed injection well locations, production and injection pipelines and surface production and injection facilities are discussed herein as required by GRO Order No. 5, Draft Outline, Section 1.E.

3. Resource Data

a. Lithology

Cores, cuttings and geophysical logs from 14 wells drilled to depths of 6,000-10,000 feet provide a means to understand the subsurface lithology at East Mesa, with optical and x-ray diffraction techniques having been used to examine the cores and cuttings.

The stratigraphy at East Mesa is a sedimentary section composed of a lacustrine and deltaic

sequence of alternating sandstones, siltstones, and mudstones of Plio-Pleistocene age, covered by a 100-150 ft. surficial layer of dune sand deposits. Immediately below these dune sands and above the deltaic sediments is a 1700-1900 ft. thick lacustrine interval that contains a significant to dominant percentage of clay-rich mudstones, particularly between the depths of 600 ft. and 1000 ft. These mudstones effectively separate the overlying fresh water sands from the more saline waters in the predominantly sandstone-siltstone sediments of the Colorado River delta sequence.

The proposed disposal zone is below 2000 feet, within the deltaic sandstones. Lithologically these sandstones are medium to fine-grained, moderately to moderately-well sorted, and quartz-rich. Detrital clasts include lithic fragments, feldspars, chert, and the usual accessories. Authigenic carbonate and quartz can occur as partial porefilling, replacement and vein materials, particularly at depths below 4000 ft. Interbedded with the sandstones are more thinly developed siltstone-mudstone lithologies. These finer-grained units progressively change in color and clay mineral content with increasing depth, starting as tan, montmorillonite- and kaolinite-rich units at shallower depths, and becoming gray, illite- and chlorite-rich units at greater depths.

A detailed overall examination of the deltaic sequence as specifically displayed in the relatively closely-spaced Republic wells at East Mesa indicates that singular lithologic units are typically 10 to 60 feet in thickness, that sandstone units are predominant, and that individual units maintain a moderate degree of lateral sedimentologic continuity.

b. Subsurface Maps and Cross-Section

The geophysical well logs from the six Republic wells and the USBR Well No. 31-1 have been examined in detail to provide an interpretation of the existing stratigraphic and structural conditions in the northern part of the East Mesa field.

In addition, the results of a recent Vibroseis reflection seismology program have been reviewed and used to expand the structural interpretation. The Vibroseis data is published in an ERDA Report titled "Utilization of Seismic Exploration Technology for High Resolution Mapping of a Geothermal Reservoir", by P. L. Goupillaud and J. T. Cherry, April, 1977.

The Plio-Pleistocene deltaic sedimentary rock sequence, present at all depths drilled below 1800-2100 ft., contains both the proposed fluid disposal zones and the underlying productive geothermal reservoir sands. The top of this deltaic assemblage of sandstones, siltstones and mudstones (shales) is represented by a distinctive and correlative shale-sand horizon that is now designated "A_1". The underlying succession of lithologic units has been correlated from well to well, with 58 specific horizons similarly designated and spaced throughout the total stratigraphic section to a depth of about 7500 feet.

Drawing No. 199-12, attached hereto and made a part hereof as Exhibit C, displays a sequence of three subsurface structure contour maps and a structural cross section through this part of the East Mesa field. As seen in the east-west cross section, a broad anticlinal axis is present near Republic Well No. 16-30. The western flank of this structure is relatively steep, with dips of as much as 35° observed in USBR Well No. 31-1. The structure dips more gently to the east, with a broad synclinal axis being present between Republic Well Nos. 16-29 and 18-28.

A series of normal growth-type faults traverses the structure. These faults strike NE-SW, dip to the NW, and cause the lithologic units to be vertically displaced by as much as 200-500 ft. at depths of about 6000 ft. Displacement decreases toward shallower depths, as the sequence of growth faults appears to have been generated at a time nearly contemporaneous with deposition of the deltaic units. It is consequently highly unlikely that they create any displacement in the overlying lacustrine beds above a depth of 1000-1500 ft.

In addition to the normal faults, two lateral faults are interpreted to be present in this area. These faults appear as a conjugate set, with the NW-SE trending fault probably being the so-called East Mesa fault referred to in recent publications on observed seismicity at East Mesa. There is no known nor suspected evidence of recent activity on any of the other faults in the area.

The combined stratigraphic and structural interpretation indicates that both horizontal and vertical fluid communication exist between the depths of 2000-7500 ft. in this portion of the East Mesa field. At least four factors have contributed to create this condition. The sand-dominated deltaic depositional environment has provided a primary horizontal stratigraphic continuity, with sufficient cut and fill present to interrupt the thinner shale interbeds. Second, the system of penecontemporaneous normal growth faults has vertically disturbed and dislocated the sediments, thereby increasing the means for vertical fluid communication. Third, the post-depositional folding and doming in this area has undoubtedly promoted the propagation of vertical tensional cracks. Finally, the more recent near-vertical lateral faults have further vertically disrupted the dominantly sandstone-siltstone lithologic assemblage. These lateral faults may actually result in

some local reduction in horizontal fluid communication as they develop due to horizontal compression. In contrast, the more prevalent normal faults should be expected to have no noticeable adverse effect on horizontal fluid movement as they are formed in response to a tensional condition present during deposition.

c. Fluid Chemistry

Produced fluids from Republic's wells at East Mesa average less than 1900 ppm total dissolved solids (TDS) and less than four ppm of total hardness (calcium). This is the lowest salinity and hardness found in any geothermal field in the Imperial Valley. Furthermore, this water is remarkably free of heavy metals which often cause environmental problems for disposal of geothermal fluids. Somewhat higher salinities have been found in the central and southern part of the East Mesa field, with a maximum of 26,000 ppm present in the Bureau of Reclamation's Well No. 6-1.

A summary of the produced water analyses data is shown in Table 1 for the three earlier Republic wells plus the shallow water supply well. The three recently completed wells (Nos. 16-30, 56-30 and 78-30), have not yet been flowed sufficiently to yield meaningful samples uncontaminated by drilling mud filtrate. The analyzed fluids from the first three deep geothermal wells are similar and are characterized by low hardness, moderate pH, high bicarbonate, and low TDS. The most notable differences between these waters and the ground water represented by the water well analysis are the lower bicarbonate, flouride and boron content of the ground water.

Only the marginally high TDS, arsenic, flouride and boron contents prevent the geothermal water from being suitable for agriculture, livestock, and human consumption. Therefore, the risk of accidental harm to the surrounding ecosystem from water spillage is minimal.

TABLE 1

EAST MESA WELL FLUID COMPARISON (mg/l)

(Unflashed Samples)

Parameter	RGI 38-30	RGI 16-29	RGI 18-28	RGI (450') Water Well
Total Dissolved Solids	1860	1761	1727	1600
Silica	148.5	149.6	86.5	10
Iron	0.04	.04	.07	0.1
Calcium	2.1	2.6	3.2	68
Magnesium	0.3	.1	.2	19
Sodium	548	506	515	410
Potassium	28	28.5	14.8	12
Bicarbonate	530	530	537	76
Carbonate	0	0	0	4
Sulfate	150	83	165	9
Chloride	450	461	401	760
Fluoride	2.8	3.3	4.0	0.5
Arsenic	.11	.10	.10	N/A
Boron	2.1	3.0	1.7	0.9
Bromide	0.25	0.17	.31	N/A
pH (pH units)	7.7	7.7	8.2	8.3

However, no surface use is contemplated at this time since it is planned that all the water, with the exception of that needed for cooling water, will be returned to the reservoir by injection. The analysis in Table 1 is for produced water without steam flash, and it is nearly representative of the residual plant waters which will be injected. The anticipated differences are those associated with the evaporation losses which will occur in the plant processing.

A chemical analysis of the flashed steam from Well No. 16-29 is shown in Table 2. The non-condensables are only 0.64 weight percent of the steam and consist primarily of carbon dioxide. Only minute concentrations of hydrogen sulfide have yet been detected in the steam. There are two major implications of this analysis. The first is that any possible environmental problems associated with flashing to the atmosphere are negligible. The second is that the low level of noncondens-ables makes it feasible to utilize a flashed steam process to drive the power plant turbines.

d. Reservoir Properties

(1) Log Analyses

Analyses of the geophysical well logs from Republic Well Nos. 38-30, 16-29 and 18-28 have been completed. Analyses of logs from the more recently completed wells (Nos. 16-30, 56-30 and 78-30) are currently underway. The principal results of the completed analyses were a determination of porosity, permeability salinity, and net sand present at each well location versus depth. The perme-ability - posity - log relationships are calibrated with core data from USBR Well No. 5-1. An improved relation may be possible when lab results from recent tests on the core from Republic Well No. 78-30 become available.

TABLE 2

CHEMICAL ANALYSIS OF
FLASHED STEAM - REPUBLIC WELL NO. 16-29

Total Noncondensables	-	0.64 wt. % of steam
Constitutents		
Carbon dioxide	-	91.4 vol. % of noncondensables
Nitrogen	-	4.3
Methane	-	3.9
Alkanes	-	0.4
Hydrogen sulfide	-	None detected

Tables 3, 4 and 5 provide a summary of the individual well data for each 250-foot increment of depth. These data generally show an excellent amount of sand development in the wells, with a gradual decrease in reservoir properties and salinity with depth. The porosity, net sand, and permeability in the producing interval, 5500± to 7500± feet, are sufficiently high to permit large flow rates with relatively minor pressure drawdowns. The validity of these calculations has been confirmed by both pressure buildup analyses and by interference testing, as discussed later.

Note that the permeabilities in the proposed injection interval, 2000± to 5000± feet (Table 3), are relatively much higher than those of the productive interval. This should allow high-volume shallow injection at low pressures as previously noted. The higher salinity of the water in the injection interval relative to the salinity in the productive interval provides assurance that injection will not degrade the shallow zone waters. Contamination of the ground water above 1000± feet will be prevented by the "shale barrier" between 1000± and 2000± feet (discussed previously in the lithology section) coupled with an adequate injection well leak monitoring system.

(2) Temperatures

The temperatures measured in each well versus depth are illustrated in Figures 3 and 4. Well Nos. 38-30, 16-29, and 18-28 have been flowed and surveyed sufficiently during the 2± years since completion to be assured that the data represents true static temperature profiles. The data from the recently completed wells

TABLE 3

REPUBLIC GEOTHERMAL WELL NO, 38-30

ZONE SUMMARIES

	Thickness (ft)				Permeability (md)		Salinity *
Interval	Gross	Net Sand	% Sand	$\bar{\phi}$	$\bar{K}$ (h) Arith	$\bar{K}$ (h) Geo	ppm NaCl
1350-1500	151	125	83	.35	1174	913	8,216
1501-1750	250	223	89	.34	1023	757	8,091
1751-2000	250	140	56	.32	756	456	10,317
2001-2250	250	155	62	.34	1064	721	10,237
2251-2500	250	166	66	.31	573	321	10,818
2501-2750	250	161	64	.31	467	256	10,113
2751-3000	250	214	86	.36	1645	1315	7,500
3001-3250	250	214	86	.33	897	534	8,043
3251-3500	250	171	68	.28	149	102	7,585
3501-3750	250	181	72	.29	322	134	6,556
3751-4000	250	166	66	.31	473	243	5,569
4001-4250	250	111	44	.31	714	286	6,117
4251-4500	250	145	58	.29	263	148	5,471
4501-4750	250	195	78	.30	432	186	3,006
4751-5000	250	189	76	.28	367	115	3,223
5001-5250	250	162	81	.30	595	205	3,029

* Produced fluid salinity 1860 ppm from the interval 6383' to 8898'

TABLE 3
(Continued)
REPUBLIC GEOTHERMAL WELL NO. 38-30
ZONE SUMMARIES

	Thickness (ft)				Permeability (md)		Salinity *
Interval	Gross	Net Sand	% Sand	$\bar{\phi}$	$\bar{K}$ (h) Arith	$\bar{K}$ (h) Geo	ppm NaCl
5251-5500	250	210	84	.30	570	187	2,564
5501-5750	250	201	80	.23	101	22	2,508
5751-6000	250	162	65	.23	63	23	3,250
6001-6250	250	183	73	.28	312	90	2,834
6251-6500	250	227	91	.31	645	266	2,134
6501-6750	250	219	88	.31	826	229	2,670
6751-7000	250	153	61	.25	287	36	3,318
7001-7250	250	76	30	.16	9	2	4,140
7251-7500	250	86	34	.19	17	6	5,814
7501-7700	200	115	58	.18	14	5	4,428
7701-8000	300	122	41	.22	106	18	3,915
8001-8250	250	93	37	.11	1.5	.6	4,378
8251-8500	250	111	44	.10	.9	.4	No Data
8501-8750	250	63	25	.11	16	.6	1,199
8751-8900	150	26	17	.07	.2	.1	No Data

* Produced fluid salinity 1860 ppm from the interval 6383' to 8898'

TABLE 4

REPUBLIC GEOTHERMAL WELL NO. 16-29
ZONE SUMMARIES

	Thickness (ft)				Permeability (md)		Salinity *
Interval	Gross	Net Sand	% Sand	$\bar{\phi}$	$\bar{K}$ (h) Arith	$\bar{K}$ (h) Geo	ppm NaCl
4800-5000	250	175	70	.26	190	54	No Data
5001-5250	250	182	73	.25	130	43	
5251-5500	250	181	72	.22	56	18	
5501-5750	250	206	82	.22	33	15	
5751-5925	174	125	72	.22	81	16	
5926-6000	250	52	21	.27	140	64	
6001-6250	250	211	84	.25	112	44	
6251-6500	250	219	88	.27	263	78	
6501-6750	250	175	70	.25	95	39	
6751-7000	250	163	65	.19	16	6	
7001-7050	50	3	6	.14	2	1	
7051-7250	200	40	20	.14	32	1	
7251-7500	250	143	57	.22	37	13	
7501-7750	250	155	62	.21	54	11	
7751-7900	150	90	60	.22	34	16	

* Produced fluid salinity 1761 ppm from the interval 6413' to 7996'

TABLE 5

REPUBLIC GEOTHERMAL WELL NO. 18-28
ZONE SUMMARIES

	Thickness (ft)				Permeability (md)		Salinity *
Interval	Gross	Net Sand	% Sand	$\bar{\Phi}$	$\bar{K}$ (h) Arith	$\bar{K}$ (h) Geo	ppm NaCl
5100-5250	250	88	35	.25	306	34	No Data
5251-5500	250	226	90	.29	458	146	
5501-5750	250	226	90	.29	658	134	
5751-6000	250	193	77	.29	529	136	
6001-6250	250	183	73	.22	42	15	
6251-6400	250	59	24	.23	86	18	
6401-6500	100	28	28	.22	30	17	
6501-6750	250	202	81	.22	29	16	
6751-7000	250	136	54	.22	127	18	
7001-7250	250	84	34	.23	213	24	
7251-7500	250	94	38	.27	994	85	
7501-7750	250	92	36	.22	198	13	
7751-7900	150	55	37	.15	2	2	

* Produced fluid salinity 1727 ppm from the interval 6413' to 7996'

EQUILIBRATED STATIC TEMPERATURE SURVEYS,
EAST MESA WELLS

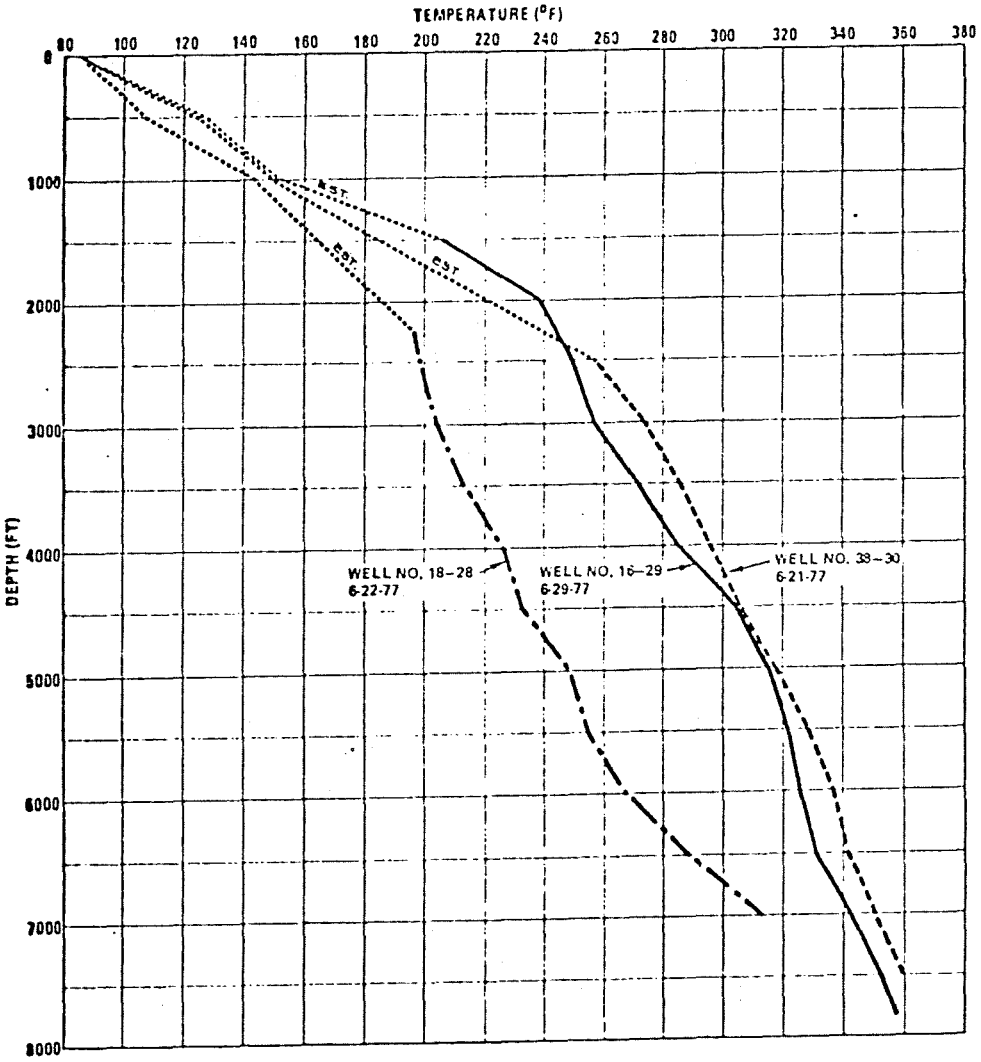


Figure 3

PRELIMINARY STATIC TEMPERATURE SURVEYS
EAST MESA WELLS

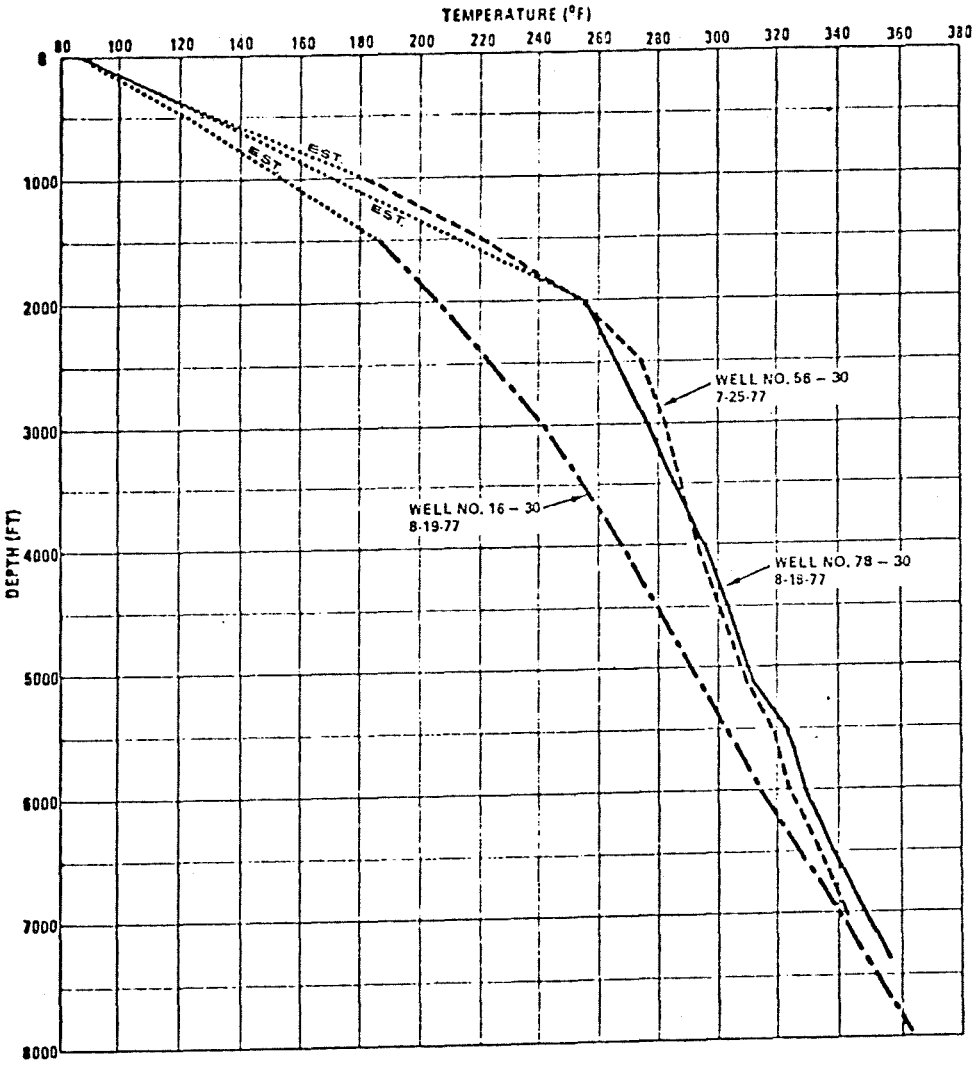


Figure 4

(Nos. 16-30, 56-30, and 78-30), however, were taken shortly after drilling and are undoubtedly at less than equilibrium temperatures.

Note the increase in slope present in all the wells except Well No. 18-28 in the interval 2500± to 3500± feet. This is indicative of convective vertical fluid flow in the reservoir and hot water influx from depth. In general, the temperature in the productive interval (5500± to 7500± feet) may be seen to range between 320°F and 360°F, while the range in the proposed injection interval (2000± to 5000± feet) is between 235°F and 310°F.

Minimum bottom-hole flowing temperatures (above the completion interval) of 338°F and 332°F have been established in Well Nos. 38-30 and 16-29, respectively, during short term flow tests. These values are very important in that they represent the volumetric average temperature of the producing interval. Such data has not yet been obtained during long term production tests, but the values can be expected to be higher, if anything, in the future. At low production rates, it may take many months for the surface produced fluid temperatures to approach the downhole flowing temperatures due to well bore heat losses. At the expected pumped rates of 800,000 + lb_m/hr, rates expected of East Mesa producers being pumped, however, preliminary calculations indicate "equilibration" between bottom-hole and surface temperatures will occur within a few days.

(3) Pressures

Bottom-hole pressure drawdown and buildup tests were run in Well Nos. 38-30,

16-29, and 18-28. The more recent wells (Nos. 16-30, 56-30, and 78-30), have, thus far, only been short-term production tested without bottom-hole instrumentation. The data were analyzed using conventional Horner plot, Miller-Dyes-Hutchinson and superposition techniques to estimate the permeability-thickness (kh) of the producing interval, and to determine if formation damage exists around the well bore. In addition, an indication of boundaries was sought, which could be combined with geophysical, petrophysical and other data to help delineate the East Mesa reservoir. A tabulation of the input data and principal results obtained from the buildup analyses are given in Table 6.

Lawrence Berkeley Laboratory has also conducted a series of interference tests between various pairs of wells in the field. A summary of the permeability and permeability-thickness data calculated by three methods (i.e., log analysis, pressure buildup, and interference testing) is given in Table 7, along with the maximum observed flow rates. Well No. 38-30 has a buildup permeability of 84 md, which is the highest of any well in the group. The permeability of 42 md found in Well No. 16-29, yields an average 63+ md for this area. The highest permeability USBR well is No. 31-1 (30 md), located immediately adjacent to the Republic leases. The interference kh between Republic's Well No. 38-30 and the USBR Well No. 31-1 is 29.8 Darcy-feet, which is in excellent agreement with the average buildup kh of 32.3 Darcy-feet between the two wells.

More recent Lawrence Berkeley Laboratory/ Republic Geothermal interference and drawdown/falloff pressure testing

TABLE 6

PRESSURE BUILDUP DATA AND RESULTS

Test Data	RGI WELLS 18-28	16-29	38-30
Flow duration, hrs	21.5	5.53	5.47
Shut-in time, hrs	9.3	22.40	24.39
Cumulative production STB	1,264(1)	4,525	5,907
Last rate before shut-in, STB/D	2,517	19,668	25,462
Producing time, hrs	17.05	5.902	6.097
Reservoir and Fluid Property Data			
Water viscosity, μ	0.210	0.185	0.185
Water FVF, RB/STB	1.078	1.085	1.088
Porosity, fraction	0.220	0.223	0.249
Total compressibility, psi^{-1}	7.570×10^{-6}	7.904×10^{-6}	8.202×10^{-6}
Well bore radius, ft	0.375	0.443	0.510
Estimated net thickness, ft	77	827	499
Perforated intervals, ft	6105-6210 6440-8000(2)	6413-6984 7231-7996	6383-7022 7271-7485(3) 7869-7998 8297-8384 8640-8898
Results			
Average permeability, md	81.94	41.96	83.50
Flow capacity, md-ft	6,309	34,698	41,666
Formage damage (skin)	-0.91	-2.28	-2.81
Distance to nearest boundary, ft	451	893	692

(1) Estimated
(2) Spinner survey showed no fluid entry
(3) Fill to 7022'

TABLE 7

COMPARISON OF PERMEABILITY AND
FLOW CAPACITY OF EAST MESA WELLS

Well	Max. observed flow rate, B/D	Avg. Permeability from buildup (md)	Permeability-Thickness (Darcy-ft) Buildup	Logs
Republic Geothermal				
38-30	50,300	84	41.7	44
16-29	31,400	42	34.7	30
18-28	15,600	82	6.3	14
Bureau of Reclamation				
31-1	21,200	30	22.2	N/A

Lawrence Berkeley Laboratory Interference Results:

38-30 and 31-1 pair: kh = 29.8 Darcy-ft

involving all six Republic wells has yet to be analyzed. This current effort involves a large amount of data which is still being digitized preparatory to computer aided analysis. However, an initial approximate "by hand" analysis generally confirms the earlier interpretations.

Static reservoir pressures are approximately hydrostatic plus 75± psig. For example, the static pressure in Well No. 38-30 at 6100 feet is 2576± psig. (The average hydrostatic gradient at 38-30 temperature conditions is 0.41 psi/ft; 6100 ft. x .041 psi/ft = 2501 psig; 2501 psig + 75 psig = 2576 psig). Because of the incremental 75± psig over hydrostatic, shut-in wellhead pressures are positive an equivalent amount. Artesian flow of the wells is thus possible even in the absence of steam flash.

In summary, it is important to note the good agreement between all three methods of measuring reservoir productive properties, as well as their correlation with maximum observed flow rates. This lends additional credibility to applying the permeability calculation results to the reservoir performance model and to the well performance predictions.

e. Production/Injection Experience

A summary of key well data and available initial production test data is given in Table 8. The three recently completed wells (Nos. 16-30, 56-30 and 78-30) have been flowed only a few hours to clean out drilling fluid. Preliminarily it can be stated that Well Nos. 56-30 and 78-30 perform as well as or better than Well No. 38-30, and Well No. 16-30 appears to be similar to Well

TABLE 8

EAST MESA WELL DATA

Well	T.D.	Est. Temp. @ T.D.	Flowing Downhole Temp. (2)	Maximum Observed Flow Rate lb_m/hr	Maximum Observed Flow Rate 10^6 BTU/day	Completion Date
38-30	9009'	387°F (1)	338°F	670,000 (3)	5,000	10/75
16-29	7998'	361°F	332°F	419,000 (3)	3,060	12/75
18-28	8001'	346°F	310°F (est.)	208,000 (3)	1,400	1/76
16-30	8000'	364°F (4)	N/A	N/A	N/A	7/77
56-30	7520'	352°F (4)	N/A	N/A	N/A	6/77
78-30	7442'	358°F (4)	N/A	N/A	N/A	8/77

(1) Fill at 6910' (348°F)

(2) Above producing interval

(3) Liquid rate only. Vapor phase (12±%) not measured.

(4) Preliminary (non-equilabrated) measurements.

No. 16-29. Detailed data from recent long term tests of Well Nos. 38-30 and 16-29 are currently being tabulated and will be available in the near future.

The highest natural flow rate measured thus far was 670,000 lb_m/hr (760,000 ± lb_m/hr including steam flash) while flowing Well No. 38-30 directly into the storage basin. During the more recent long term testing, this well demonstrated a sustained natural flow capability of about 400,000 lb_m /hr against 30± psig backpressure with only a 200± psi bottom-hole drawdown. Subsequently, the well was pumped continuously for more than thirty days using a line-shaft turbine pump set at 420± feet. The maximum rate of about 475,000 lb_m/hr attained during pumping was limited due to the disposal system capacity.

Well No. 16-29 flowed to the basin at a maximum rate of 419,000 lb_m/hr (475,000± lb_m/hr including steam flash). A sustained natural flow capability of about 335,000 lb_m/hr against 30 psig backpressure was achieved in the more recent tests. Continuous pressure/temperature profiles, observed during flow with experimental instruments from Denver Research Institute, suggest that cold water influx at the intermediate casing shoe may be occurring. This could have a substantial constraining influence on flow capability. Confirmation testing is underway, with remedial work planned if indicated, prior to resumption of long term testing.

Two high volume line-shaft turbine pumps designed for 1000± foot setting depths are currently on order and should be ready for testing by May 1978. It is anticipated that the five producers for the 10 Mw plant (including Well Nos. 16-29, 56-30 and 16-30 already drilled) should be capable of 800,000 to 900,000 lb_m/hr each when equipped with

such pumps. This will be an adequate supply for the plant which requires 4,300,000± lb_m/hr of 335°F water initially to generate 10 Mw. After integration with the planned 48 net Mw plant in early 1980, the efficiency of the 10 Mw plant will be nearly twice as great (i.e., about half as much feed water required) due to the addition of a second stage flash.

Well No. 18-28 was found to be on the flank of the thermal anomaly and it is too cold to be an economic producer. It was capable of only 208,000 lb_m/hr artesian flow and was ultimately converted to injection service. During the recent long term testing of Well Nos. 38-30 and 16-29, it was possible to inject about 300,000 lb_m/hr at 400 psig wellhead pressure on a sustained basis into Well No. 18-28. Initial plugging problems were overcome by acid treatment and installation of finer filters (10 μ rather than 50 μ) to prevent suspended $CaCO_3$ precipitates from entering the well bore.

Profile surveys showed that less than 200 feet of the 1800 feet of perforations open in Well No. 18-28 were actually taking fluid. Presumably this was due to an inability to flow the well at high enough rates to remove the initial drilling mud wallcake. Current plans are to plug back the well and jet perforate about 1200 feet of the proposed shallow injection zone. Long term testing of the producers will then resume.

It is anticipated that the three injectors for the 10 Mw plant (including Well No. 18-28) will be able to handle the residual 4,000,000 + lb_m/hr water at very low wellhead injection pressures due to the high permeability sands present in the 2,000± to 5000± foot injection zone.

f. Reserves and Expected Performance

The productive limits of the East Mesa reservoir are yet to be determined by additional drilling and testing. An approximation of reserves for Sections 29 and 30 is possible, however, based on heat content. The approach used herein is analogous to a volumetric calculation for determination of conventional oil and gas reserves. It is comprised of essentially three steps. First, the total initial heat content (enthalpy) of the reservoir was calculated between a bottom of 9000 feet, approximately the 1 md permeability level, and a top defined by a 300°F surface. Second, an estimate was made of the portion of this initial heat content that can be expected to be recovered during the economic producing life of the area by using reservoir simulation studies of a single five-spot reinjection pattern. Lastly, a conversion efficiency was developed which relates the heat content of the produced water to the electrical energy output.

Note that this approach is conservative in two respects as discussed earlier. First, no credit is taken for recharge of the reservoir due to thermal convection through the fracture system. There is sound geological evidence that this will probably occur, with the net effect being higher temperatures and longer reservoir life. Second, the reservoir model assumes that a five-spot pattern will be employed to reinject the cooled residual water. In reality, it is planned to prolong reservoir life and to improve sweep efficiency by using a peripheral flood. Therefore, the five-spot prediction will probably prove to be pessimistic.

A more sophisticated approach to reserves and performance prediction will only be warranted after additional drilling and testing has yielded a refined picture of the heat and

reservoir property distribution. An ultimate evaluation will also require information on the aquifer influx magnitude which can only be obtained by long-term production.

(1) Initial Heat Content

The first step in calculating the total initial heat content of the reservoir for Sections 29 and 30 was to construct a set of isothermal surface maps which show the depth to several selected reservoir temperatures. Figure 5 provides an example of the 350°F map. The maps were based on the static temperatures measured in the wells, with additional input provided by the data from the existing network of shallow temperature observation holes.

Using the maps, the bulk of volume of each 500-foot depth interval and its average temperature were determined from isothermal surfaces by numerical integration. The total initial heat content of each interval can then be calculated by:

$$\text{Total Heat Content} = \text{Bulk Volume} \cdot (T-T_o) \cdot \rho c$$

Where T is the reservoir temperature, T_o is the reference temperature (taken as 32°F) and ρc is the effective volumetric heat capacity of the total rock and fluid system. The last term (ρc) may be calculated as follows:

$$\rho c = \rho_r c_r (1 - \phi \cdot NS) + \rho_w c_w \phi \cdot NS$$

Where ρ_r and ρ_w are densities of the rock and fluid, respectively, c_r and c_w are the specific heat capacities of the rock and fluid, respectively; ϕ is the porosity of the productive portion of the rock; and NS (net sand) is the fraction of the interval which is productive.

EAST MESA
350°F ISOTHERMAL SURFACE
DEPTH CONTOURS

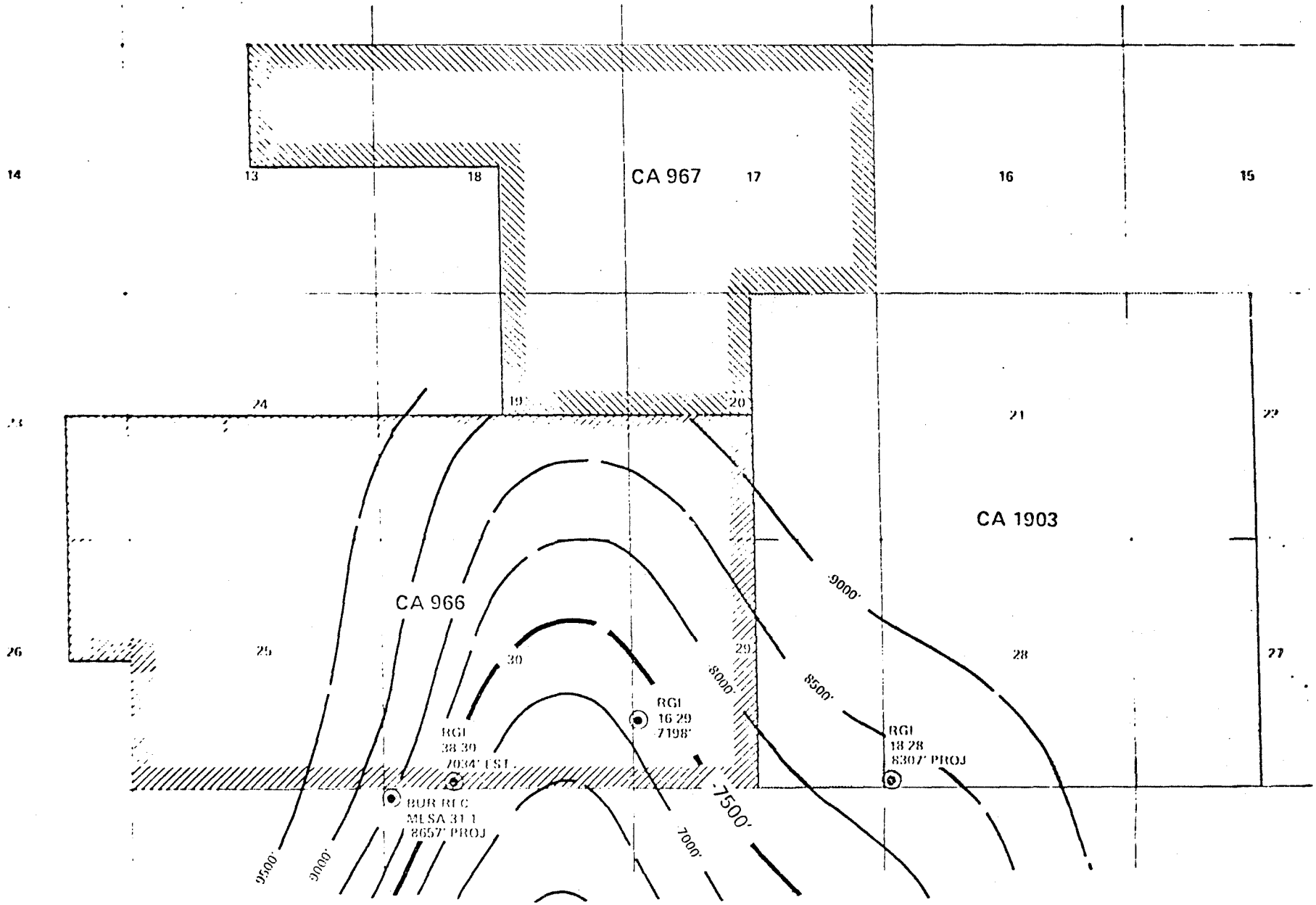


Figure 5

Basic input and summary results of the calculation for each Section are shown in Table 9. Porosity and net sand values derived from Well Nos. 16-29 and 38-30 were taken to be representative of Sections 29 and 30 respectively. Total initial heat content for the two sections is shown to be 2.14×10^{15} BTU.

(2) Heat Recovery Efficiency (Reservoir Simulation)

Reservoir simulation studies were undertaken to predict how much of the initial heat content could be recovered. Specifically, the temperature, pressure and rate behavior versus time were investigated for various conditions. The types of field development considered included: (1) straight depletion without reinjection; (2) peripheral reinjection; and (3) five-spot reinjection. Also, various rates and pattern sizes were investigated as well as the effect of an infinite aquifer.

In summary, it was found that: (1) an aquifer alone (having the same properties as the reservoir) is insufficient to maintain pressure; (2) for some combinations of withdrawal rate, spacing and permeability, peripheral injection combined with the contributions from the aquifer will maintain adequate pressure; (3) whenever the peripheral flood fails to maintain adequate pressure for the desired withdrawal rate, pressure can always be maintained by going to a pattern flood such as a five-spot.

A typical simulation result was previously illustrated in Figure 2. In this case, a 40,000 B/D producer on 40-acre spacing initially produces at 355°F. The reinjected water temperature is assumed to be

TABLE 9

EAST MESA FIELD - SECTIONS 29 & 30

PRELIMINARY RESERVE ESTIMATE

Section	Average Reservoir Temperature (^{o}F)	Average Sand Porosity (fraction)	net sand (fraction)	Bulk Volume ($ft^3 \times 10^{10}$)	Total Initial Heat Content ($BTU \times 10^{14}$)	Reserve (Mw-Years)
29	334	0.17	0.60	8.363	8.732	1315
30	335	0.23	0.58	11.701	12.625	1900
	335	0.20	0.59	20.064	21.357	3215

$\rho r = 165 \frac{lbs}{ft3}$; $\rho w = 56.7 \frac{lbs}{ft3}$; $c_r = .19 \frac{BTU}{lb^{o}F}$; $c_w = 1.12 \frac{BTU}{lb^{o}F}$

200°F. The economic life of this well is approximately 30 years or 265°F. For the reserve calculation, this "base case" is used to determine the fraction of original heat content of the rock and fluid system which would be produced in the hot water over the economic life of the well. The total amount of heat (enthalpy) contained in the produced fluids is equivalent to over 90 percent of the original heat-in-place in the reservoir, but about half of this heat is returned to the reservoir by means of the reinjected water. Therefore, the net heat produced is about 45 percent of the original heat-in-place. During the 30-year period, approximately three pore volumes of water were produced and reinjected. Thus, it is concluded for East Mesa conditions that the net producible heat is approximately equal to 45 percent of the original heat-in-place or 9.6×10^{14} BTU for Sections 29 and 30 combined.

(3) Conversion to Electricity

It is desirable to express geothermal reserves in electrical terms (i.e., megawatt-years), rather than in volume or mass of hot water. Reference must therefore be made to a specific power plant design. Figure 6 shows the power output for the one-stage and two-stage flashed steam process as a function of temperature.

The proposed 10 Mw plant will initially employ a single-stage flash process. Later it will be integrated into the planned two-stage flash 48 net Mw plant. This process was selected for East Mesa because: (1) it relies on proven, existing technology; (2) it can be designed and built in time to meet the incremental power needs of the Imperial

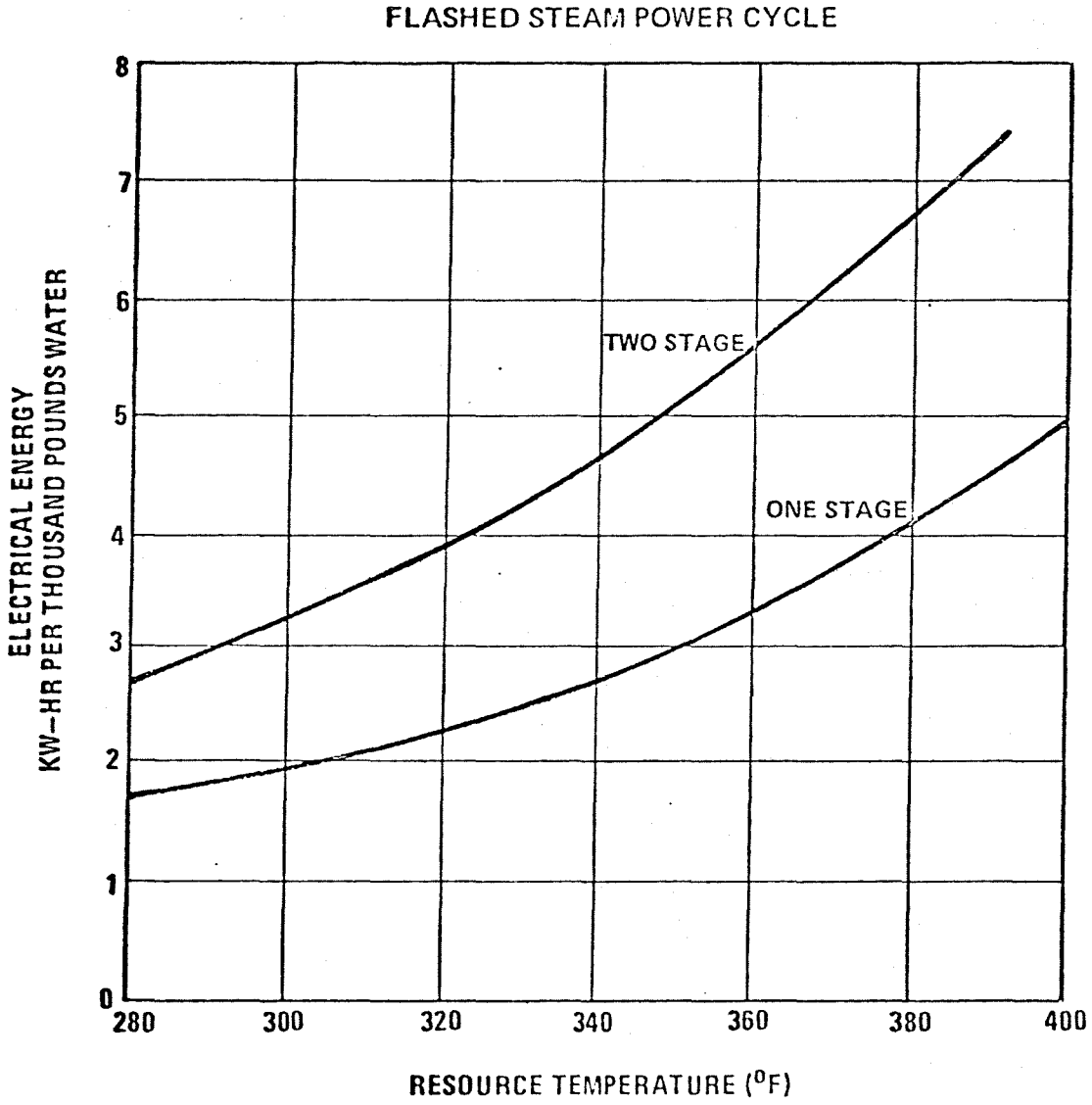

FLASHED STEAM POWER CYCLE
ELECTRICAL ENERGY
KW-HR PER THOUSAND POUNDS WATER
8
7
6
5
4
3
2
1
0
TWO STAGE
ONE STAGE
280
300
320
340
360
380
400
RESOURCE TEMPERATURE (°F)

Figure 6

Irrigation District by 1980; (3) it is well suited to the low salinity and low noncondensables found in Republic wells; and (4) it will probably generate the lowest-cost electricity under the specific East Mesa temperature and water chemistry conditions.

Assuming a produced water temperature of 335°F, two-stage flash and a reinjected water temperature of 200°F, the calculated conversion efficiency,* based on Figure 6, is approximately 11 percent. The resulting calculated electrical energy reserve for Sections 29 and 30 is shown in Table 9. These calculations are based on a net producible heat equal to 45 percent of the original heat-in-place (as determined from the five-spot simulation results) and a conservative conversion efficiency of ten percent. The total reserve amounts to 3215 megawatt-years, which is 107 megawatt installed capacity for a 30-year life. These reserves are clearly adequate to support the proposed 10 Mw and planned 48 net Mw projects.

4. Representative Drilling Program for East Mesa Production Wells

a. Zone of Completion

Production wells will be completed in the Borrego Formation described in the geological section. The production interval will be approximately from 5500 feet to 7500 feet (all depths referenced to KB, which averages approximately 52 feet above MSL).

$$* \text{ Conversion Efficiency } \% = \frac{\text{BTU Equivalent of Plant Electrical Output}}{\text{BTU Content of Net Produced Heat}} \times 100$$

Where: BTU content of net produced heat = BTU content of produced fluid - BTU content of injected residual fluid.

b. Casing and Cementing Program

The casing program will be one of the following:

Depth	Program 1	Program 2
Conductor Pipe 90'	20"	24"
Surface Casing 1500'	13-3/8"	16"
Intermediate Liner 5500'	9-5/8"	11-3/4"
Production Liner 7500'	7"	9-5/8"

Two casing size programs are proposed to allow flexibility to utilize any new data resulting from current and proposed testing operations. To date, one well has been completed with the larger casing program, except that an 8-5/8" production liner was run instead of the proposed 9-5/8" production liner.

The wellheads on the non-pumped wells will consist of a 13-3/8" S.O.W. x 12" - 400# RTJ Model SU casing head with two 2" flanged side outlets, two 12" - 600 series manual gate valves with 400# RF flanges, a 12" tee with 400# RTJ flanges, a 6" - 400# RTJ flanged crown valve and two 12" series 400# manual gate valves for the wing valves.

The surface casing will be cemented to the surface using API class "G" cement mixed 1:1 with Perlite plus 2% gel and 35% silica flour. The slurry density will be 95#/ft.^{3}. A tail slurry of 200 sacks of class "G" cement with 35% silica flour with a density of 117#/ft.^{3} will be used for additional strength around the casing shoe. The intermediate liner will be cemented with the same

basic slurries as above; however, sufficient retarders will be added based on logging temperatures to give adequate pumping times.

After waiting on cement for eight hours, the casing will be slacked off and the casing pressure tested to 1000 psi for 30 minutes. Liner laps will likewise be tested.

c. Mud Program

The mud program from surface to TD will be lightweight (8.8-9.2 PPG), low solids, fresh water, clay base drilling fluid treated with lignite for temperature stability, and bicarbonate of soda for cement contamination. Desanders and desilters will be run in order to keep the solids as low as possible. A cooling tower will be installed in the mud system and the mud pumped through this cooling tower when the return mud temperature exceeds 160°F (71.1°C).

d. Safety Provisions

After setting surface casing, an API class 3000 psi double hydraulic pipe and blind ram blowout preventer will be installed above a 12" gate valve with 400# RTJ flanges which will be just above the casing head. On those wells drilled with the large casing program, a single blind ram will be installed instead of the 12" gate valve. The casing head will have two side outlets with two flanged valves on each outlet. One side will be connected to the original choke manifold, the other side will be connected to a pumping unit as a kill line with a back pressure valve in the line for pumping into the well, if necessary. A fill-up line will be installed above the BOP equipment so that the hole can be filled during trips, and the amount of fluid pumped into the well while tripping will be monitored. The hydraulic control unit for the BOP equipment will have two operating stations, one on

the rig floor and one at least 50 feet from the wellhead. At all times the mud flow line temperature and the mud pit level will be monitored. A pit level warning device will be installed. Gases in the mud return will be monitored. Special provisions for handling hydrogen sulfide are not planned since hydrogen sulfide has not been encountered in any exploration and delineation wells at the East Mesa KGRA.

The BOP equipment will be pressure tested to 1000 psi when installed and at least once every seven days thereafter. This will include testing of all drill string back pressure valves, full opening valves, stand pipe and choke manifold.

A drill string back pressure valve along with a full opening safety valve will be maintained on the rig floor with adequate subs to fit all connections in the drill string.

Each drilling crew will be instructed in blowout control procedures and the contractor will be required to have at least one pit drill per crew per week.

In the event of an emergency, the drilling contractor will have the names and telephone numbers of the appropriate company personnel to notify. Please refer to Section E, Emergency Contingency Plan, of this Plan of Operation for more detailed emergency procedures.

5. Proposed Manner of Commercial Utilization, Including Byproducts

Steam produced from the geothermal resource will be utilized to drive a single admission, flashed steam turbine generator having a nominal capacity of 10 Mw. During the first year of operation electric power not needed for internal plant use including well pumping and fluid injection will be available for sale to the IID. After the first

year the electric power will probably be utilized for operation of downhole pumps in producing wells linked to Republic's proposed 48 Mw plant (to be discussed in subsequent Plans of Operation). A generalized drawing of the lineshaft turbine pumps proposed for use is attached as Figure 7. The only byproducts of the power plant will be geothermal fluids separated from the steam. These fluids will be injected into underground formations. Further details are contained in Republic's Plans of Utilization and Injection.

6. Surface Equipment Installations

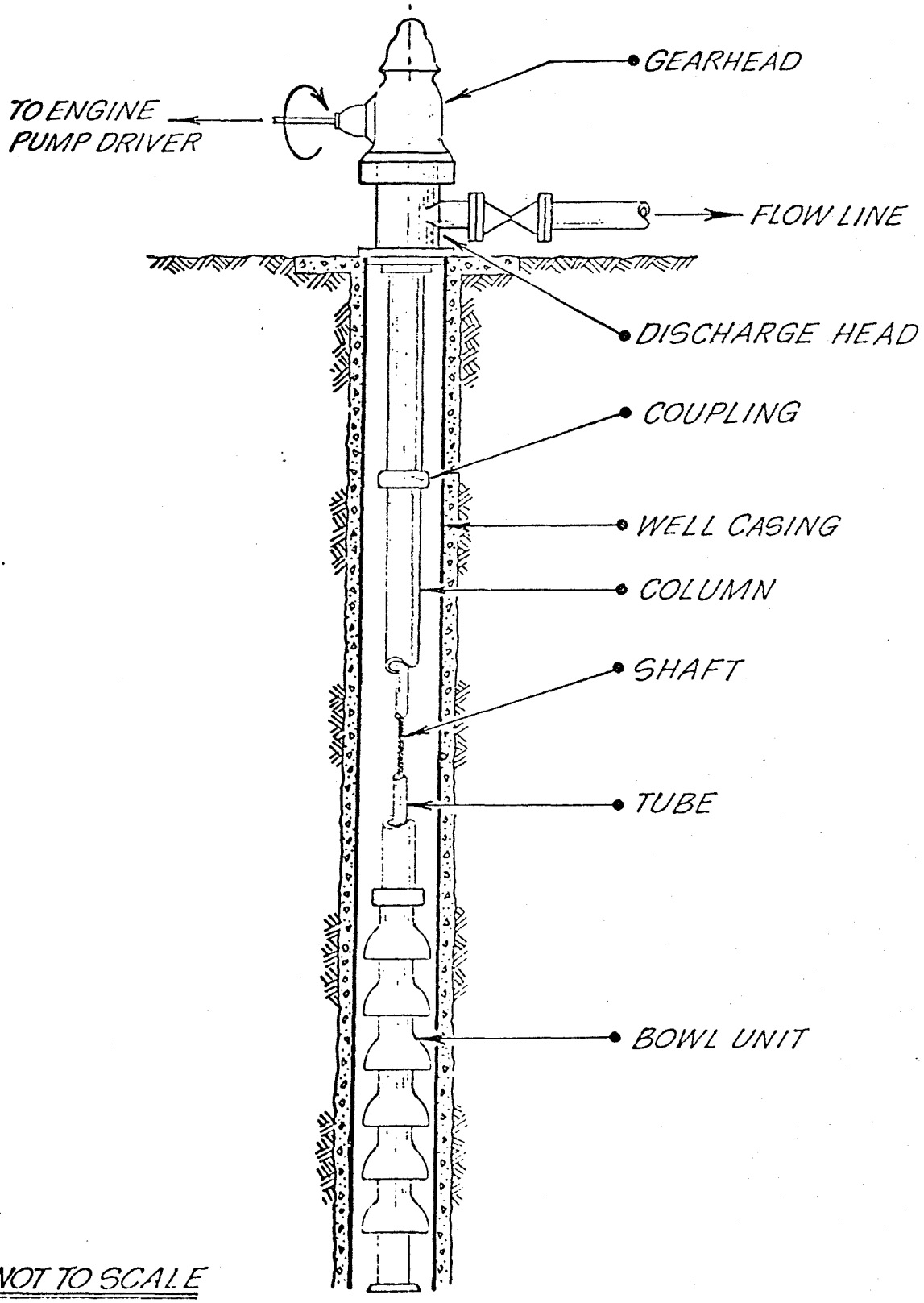
a. Pipelines

Republic proposes to use twelve and sixteen inch diameter steel flowlines to carry the geothermal fluids from the producing wells to the power plant separation facilities and to carry liquids from the power plant to injection wells. The pipelines will be installed on the surface and routed along existing roads. Expansion loops will be installed as necessary (at intervals of approximately one-quarter mile) to prevent mechanical damage to the pipe from thermal expansion. The lines will be externally insulated to minimize heat loss from the well to the power plant. During installation of the pipelines, 20-25 feet along the side of the road will be temporarily disturbed. After construction is complete, there will be 5-6 feet of permanent surface disturbance. Construction of expansion loops will result in a temporary surface disturbance of approximately 40 square feet and permanent surface disturbance will be approximately 25-30 square feet.

b. Separators

A separator or flash tank will be installed at the power plant site to separate the steam from the produced fluid. The separator will

LINESHAFT TURBINE PUMP INSTALLATION



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handle five producing wells and will be designed to operate at approximately 55 psig. Steam from the separator will go directly into the turbine inlet. The separated liquid will be pumped from the separator and injected into underground formations.

c. Metering Systems

An orifice type meter will be installed on the inlet line to the steam separator to measure the total liquid rate from the producing wells. An orifice meter will also be installed on the water injection line leaving the plant site to measure the total volume of water injected.

d. Transmission Lines

It is proposed that Republic will run a transmission line from a substation built at the power plant to an existing 34.5-kv transmission line located approximately one and one-half miles south of the plant site. The transmission line will follow existing roads from the power plant to the tie-in point. More detailed discussion is contained in Republic's Plan of Utilization.

e. Capacities

The flowlines are being designed to handle the maximum production from each well. Current information indicates that individual well production rates will be from 60,000 to 75,000 barrels of water per day. Current plans are for steam separators to be designed to handle 360,000 barrels of water per day and 25,500 lbs./hr. steam. The steam turbine driven generator will develop 10 Mw nominal power output. The liquid injection system will be designed to handle 341,000 barrels of water per day at approximately 150 psig surface injection pressure.

f. Safety Provisions

All applicable codes and regulations will be utilized during plant construction. All equipment will have protective and shut-down systems designed to prevent damage to equipment or personnel as a result of equipment malfunction.

7. Proposed Liquid Disposal Program

Republic proposes to reinject geothermal fluids produced during testing and production. Wells proposed for use as injection wells are delineated on the attached map, Drawing No. 199-11. Details of proposed injection operations are discussed in Republic's Plan of Operation, Injection.

8. Source of Water Supply and Road Building Material

In accordance with Section 270.34, water for operations will be supplied by the previously approved well, WW-1, a shallow water well located in the northwest corner of Republic's East Mesa maintenance yard.

The access roads for the existing and proposed production wells have already been built, as has the road to existing Well No. 18-28, a proposed injection well. No road building material will be obtained from federal lands for the access roads to proposed injection well locations. If road building material such as gravel is needed, it will be trucked from outside commercial sources.

9. Additional Information

The following, submitted by Republic Geothermal to the Area Geothermal Supervisor, are incorporated herein and made a part hereof by reference:

a. Plan of Operation, approved as effective September 12, 1975 (EA 12).

b. Supplemental Plan of Operation, approved as effective December 15, 1975 (EA 29).

c. Plan of Operation, approved as effective December 1, 1976 (EA 61).

d. Supplemental Plan of Operation, approved as effective September 16, 1977 (EA 81).

e. Amended Plan of Operation, submitted June 14, 1977 (EA 86).

C. ENVIRONMENTAL PROTECTION

The following measures will be taken for protection of the environment:

1. Fire

a. All local, state and federal fire protection standards applicable to Republic's activities will be observed.

b. Vegetation on the lease is sparse and low-level. It will be cleared only to the extent needed for proper operation. Smoking will be allowed only in designated areas.

c. Water and fire extinguishers will be available at each site during drilling activities and at a central location during testing and construction activities in the unlikely event a fire should occur.

2. Soil Erosion

Due to the essentially level topography at East Mesa, the infrequent rainfall and the lack of surface water, soil erosion is not anticipated to be a problem. Well location sites, surface facilities and access roads are designed to disturb only the minimum amount of surface necessary for efficient operations. Off-road vehicle use will be prohibited except where necessary. Best efforts will be made to minimize disturbance of the perennial woody vegetation. For the proposed wells, those portions of the drillsite required for the proposed production operations will be covered with gravel to prevent erosion and efforts will be made to revegetate those cleared areas not required after drilling. For pipelines, cleared areas not required after construction and installation will be allowed to revegetate naturally.

3. Pollution of the Surface and Ground Water

a. Surface Water

Surface waters within Republic's East Mesa

leasehold are limited to one very short section of the East Highline Canal in the extreme southwestern corner of Lease No. CA 966. The remainder of the area is devoid of easily recognizable stream channels.

The low salinity of the geothermal fluids produced from Republic's East Mesa wells, lease stipulations which restrict drilling within one-quarter mile of the canal, and the distance to the nearest well proposed under this Plan of Operation from the canal all indicate that the proposed development will have no deleterious effect on the quality of water in the East Highline Canal.

b. Ground Water

There are no natural ground water sources such as springs or seeps within Republic's East Mesa leases. The California Regional Water Quality Control Board considers the ground water in the vicinity of Republic's leases saline and not beneficially used.

All of Republic's previously approved Plans of Operation on East Mesa have been conducted under approved Orders No. 76-35 and No. 76-64(Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region. These Orders have been previously submitted to the USGS-AGS.

The Board has determined that Republic's discharge of geothermal fluids into unlined temporary storage basins is acceptable for fluids of less than 2300 mg/l. They have approved the discharge of geothermal fluids onto roads and well sites in an amount not to exceed 126,000 gallons per day or 232 acre-feet for the life of the project. This Order also permits the disposal of geothermal waste fluids by subsurface injection into the zone of extraction or into zones which contain a total dissolved solids content that is equal to or greater than that contained in the zone of extraction.

Republic will also protect the area's ground water by complying with the provisions of GRO Order No. 2 or exceptions to this Order as approved by the Area Geothermal Supervisor for East Mesa and the conditions of approval for Republic's Plan of Operation, Injection.

Drilling Muds will contain no toxic materials or materials which could contaminate the ground water. All pipelines will be properly insulated to prevent leakage.

4. Fish and Wildlife

a. There are no fish in the area.

b. The proposed production and injection testing will not disturb additional habitat. Although the construction of the proposed well pads will result in some unavoidable permanent destruction of habitat, this has already been evaluated in Environmental Analyses for the previously approved Plans of Operation. Construction of the proposed pipeline will result in temporary surface disturbance of approximately twenty to twenty-five feet and permanent surface disturbance of approximately five feet along one side of the approved and existing access roads. No other surface disturbance is anticipated.

Because of the very minor amount of habitat disturbance and the homogeneous nature of the vegetation at East Mesa, it is anticipated that any displaced wildlife can be accommodated on nearby lands. To help provide replacement habitat, removed vegetation and excess soil shall be stacked in several piles at a reasonable distance from the roads and drillsites. The area temporarily disturbed for construction of the flowlines will be allowed to revegetate.

5. Air and Noise Pollution

a. Air

Air quality should not be significantly degraded during these proposed operations. All operations will be conducted with the approval of the Imperial County Air Pollution Control District. To date, the concentration of the noncondensable gases in the wells drilled at East Mesa has been about 1.5 percent, and only minute concentrations of hydrogen sulfide have been detected. Because the concentration of these gases is so low and there are no known deleterious constituents in quantities harmful to the environment, Republic does not anticipate that the proposed operations at East Mesa will significantly degrade the existing ambient air quality.

Dust from cleared roads and drillsites shall be suppressed by distribution of geothermal fluids on these areas, as evaluated and approved by the California Regional Water Quality Control Board.

b. Noise

Noise is expected to be of minor concern in the development of Republic's East Mesa geothermal field. Noise levels will be maintained within the limits prescribed by the County of Imperial, the Bureau of Land Management and the Occupational Safety and Health Administration. Drilling rig engines and compressors will be equipped with mufflers.

Noise impacts on wildlife at East Mesa will probably be minimal because of the relatively low intensity and steady, continuous nature of most of these noise emissions. The East Mesa area itself is also very isolated from any human receptors. The extant ambient noise levels on East Mesa are usually very low, but are frequently punctuated by the

sounds of aircraft overflights and explosions from the nearby military gunnery range. Occasional off-road vehicle use of the area also adds to the ambient noise levels.

6. Hazards to Public Health and Safety

Public health and safety shall be ensured through the use of appropriate equipment, operating procedures and notices. Appropriate warning signs will be posted before curves on the access roads and on all pipelines and testing equipment. Each well will be posted with a sign indicating the well name, the designated operator and an emergency phone number. Supervisory personnel will be on-site during drilling and testing operations. All equipment will be secured within a maintenance yard encircled by a chain-link fence when not in use. During testing activities the location pad will be surrounded by a locked chain-link fence. Wells will be chained and locked behind a chain-link enclosure when completed. All drilling shall be conducted in accordance with all state and federal requirements, specifically GRO Order No. 2.

7. Section 270.34, (i) and (j)

a. Methods for Disposal of Waste Material

Waste waters will be disposed of as indicated in part 3 b. above. Portable chemical sanitary facilities will be used by personnel on the drilling or construction sites. These will be maintained and wastes disposed of by a local contractor. Permanent sanitary facilities will be located at the power plant site after construction is complete.

The site will be kept clean and any trash or debris will be taken to an approved dump. Drilling muds will be neutralized and spread on the surface of existing and/or proposed roads or trucked out of the area to a Class I dump. Republic favors the former method of disposal.

b. Delineation of Potential Environmental Impacts

Republic anticipates that there should be only negligible environmental impacts from these proposed operations over and above those from existing approved operations.

c. Environmental Monitoring and Any Additional Information

Noncondensable gases will be monitored in accordance with the requirements of the Imperial County Air Pollution Control District.

Geothermal fluids will be monitored and disposed of in accordance with the requirements of Order No. 76-64(Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region.

Republic has submitted to the Supervisor a Program for Collection of Environmental Baseline Data for Federal Geothermal Leases CA 966, CA 967 and CA 1903 at East Mesa, in accordance with 270.34 (k).

Republic is prepared to submit, upon notification to do so, any further information not included herein which the Supervisor may require. Republic is also prepared to carry out provisions for monitoring deemed necessary by the Supervisor to ensure compliance with the regulations and to participate in the collection of data concerning the existing air and water quality, noise, seismic and land subsidence activities, and ecological systems in the vicinity of the site.

d. Approximate Crew Size, Probable Type and Location of Housing and Support Facilities

Approximately twelve to fifteen people may be working on the location at any one time during drilling and/or production testing operations. No housing or special support facilities will be required on-site during these operations due to proximity of existing facilities.

D. DISCUSSION OF OTHER ENVIRONMENTAL CONCERNS

The presence of desert buckwheat (Erigonum deserticola) in areas of Republic's East Mesa leases has recently been identified. Although this plant species was not among the 1,700 plant species listed for possible endangered status (Federal Register, June 16, 1976) as provided by the Endangered Species Act of 1973, it is included among more than 3,000 plants nominated by the Smithsonian Institute as a candidate threatened species.

The distribution of desert buckwheat is apparently more widespread than originally thought. The Bureau of Land Management has recently identified the plant throughout the East Mesa in Imperial County. Republic proposes to work with the Bureau of Land Management and any other interested parties to determine the actual distribution of desert buckwheat and to determine necessary protection measures, if any.

In any event, Republic expects that the operations proposed herein will have a negligible impact on this plant species due to the very minimal amount of surface disturbance. In addition, Republic's entire East Mesa leasehold is being surveyed by qualified botanists as part of Imperial County's Environmental Impact Report for Republic's Application for a Conditional Use Permit for a Geothermal Development Project. If it should be determined that the proposed operations could adversely affect desert buckwheat, Republic will work toward a plan to protect the species.

E. EMERGENCY CONTINGENCY PLAN

If any emergency develops or is determined to be impending, appropriate control procedures will be initiated. The specific procedures will vary greatly depending on the nature of the problem. Examples of possible emergencies are: a well control problem (well blowing steam, hot water or other well effluent with loss of means to shut in or divert the flow); a spill of geothermal fluid; fire; accidents or injuries; etc. The following measures will be taken:

1. If any injuries have occurred, arrangements will be made to care for the injured party(ies).

   Chalfont Service Corporation
   496 W. Euclid Road
   El Centro, California 92243
   (714) 352-2711

   First aid supplies will be available at the drillsite during drilling operations as well as at the power plant site during all other operations. At least one person on each crew will be trained in first aid. In addition, copies of Republic's comprehensive booklet, "Safety Begins With You: A Handbook of Safe Industrial Practices and Fundamental First Aid Techniques" will be available at the drillsite and/or plant site.

2. If there is a threat to local residents, the Sheriff will be notified as soon as possible.

   Imperial County Sheriff's Department
   150 S. 9th
   El Centro, California 92243
   (714) 352-3111

3. The Field Production Superintendent will be notified and consulted immediately.

   Carl E. Fisher
   El Centro, California 92243
   (714) 352-4434, Unit 4176
   Home: (714) 353-3544

4. The Vice President, Production, will be advised and consulted as soon as practicable.

Dr. James Barkman
Vice President, Production
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

5. Field supervisory personnel will contact the Staff Drilling Engineer or Senior Facilities Engineer and consult with him as to any further or supplemental steps which may be necessary or advisable.

Dr. Robert Nicholson
Staff Drilling Engineer
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

Michael J. Walker
Sr. Facilities Engineer
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

6. The Vice President, Land, will be advised and consulted as soon as practicable. He may consult with Republic's environmental staff.

Timothy M. Evans
Vice President, Land
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

7. All prescribed safety practices and procedures will be followed. All members of the drilling, well testing, construction or field operations crews will perform duties assigned for the specific purpose, following specified safety practices and procedures.

8. Every effort will be made to minimize possible deleterious environmental effects of the emergency and the operations performed to control the emergency.

9. A pump truck will be in the vicinity, and earth moving equipment may be obtained from local contractors, if necessary.

Henry Abeyta
360 W. El Dorado Road
El Centro, California
(714) 352-2545

Ryerson Ditch-Liners
50 East Highway 80
El Centro, California
(714) 352-4341

Merrill Ditch-Liners, Inc.
51 East Highway 80
El Centro, California
(714) 353-0193

10. The Staff Drilling Engineer or Senior Facilities Engineer will:

(a) Brief his immediate supervisor (Vice President, Production) on the situation and course of action underway.

Dr. James Barkman
Vice President, Production
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

(b) Contact the following agencies or regulatory bodies as soon as practicable and in the following order:

U. S. Geological Survey
Conservation Division
Western Region
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111, Ext. 2845

Bureau of Land Management
1695 Spruce
Riverside, California 92507
(714) 787-1462

(c) If the emergency involves a well control problem or other well operations, he will also notify the following agency:

Department of Conservation
State of California
Division of Oil and Gas
Geothermal Unit
1416 Ninth Street
Sacramento, California 95814
(916) 445-9686

11. The Vice President, Land, or Republic's environmental personnel will notify as soon as possible the following additional state and local agencies:

California Regional Water
Quality Control Board
Colorado River Basin Region
73-271 Highway 111
Suite 21
Palm Desert, California 92260
(714) 346-7491

Imperial County Air Pollution
Control District
935 Broadway
El Centro, California 92243
(714) 352-3610

Imperial County Planning
Department
Courthouse
El Centro, California 92243
(714) 352-8184

Resources Agency
State of California
Department of Fish and Game
Region No. 5
350 Golden Shore
Long Beach, California 90802
(213) 435-7741

U. S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, California 95825
(916) 484-4657

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Area Geothermal Supervisor's Office
Conservation Division, MS 92
345 Middlefield Road
Menlo Park, CA 94025

AREA
CA
Imp
EastMesa
PO. Repub

Memorandum

To: INTERESTED PARTIES

From: Acting Area Geothermal Supervisor

Subject: Plan of Operation, Republic Geothermal, Inc., Federal Leases CA-6217 and CA-6218, East Mesa KGRA, Imperial County, CA
Ref: 2403-01 CA-6217 (POO for EA #146-80)

Republic Geothermal, Inc. has submitted a Plan of Operation, Exploration, in accordance with 30 CFR 270.34 to construct well sites, access roads and drill nine (9) deep exploratory wells on Federal Leases CA-6217 and CA-6218 in the East Mesa KGRA, Imperial County, California. A copy of the Plan of Operation is enclosed for your review and files.

An Environmental Assessment (EA #146-80) will be prepared by the office of the Area Geothermal Supervisor for the proposed action. Numerous field inspections have been held in the East Mesa area in conjunction with previous EA's and public hearings were conducted by the Geothermal Environmental Advisory Panel (GEAP). Consequently, no additional field inspection is considered necessary at this time. You are encouraged to visit the site at your own convenience. Any inquiries should be directed to Mr. Bernie Moroz, District Geothermal Supervisor, Kietzke Plaza, Bldg. D, Suite 137, 4600 Kietzke Lane, Reno, Nevada (Tel: (702) 784-5676, FTS: 470-5676).

We urge you to send written commentary and will appreciate hearing from you even if you are of the opinion that the existing regulations, lease terms, and operational orders provide adequate environmental protection.

All comments concerning the proposed actions should be received no later than January 25, 1980 by:

Acting Area Geothermal Supervisor
U.S. Geological Survey
Conservation Division
345 Middlefield Road - MS 92
Menlo Park, CA 94025
415-323-8111 x 2848; FTS 467-2848

All comments will be given serious consideration in the preparation of the Environmental Assessment and any subsequent conditions of approval.

The Area Geothermal Supervisor's office will routinely distribute copies of the completed final EA to the surface managing agency, the lessee, the Geothermal Environmental Advisory Panel (GEAP) and the U.S. Fish and Wildlife Service. Other interested parties may receive a copy of the final EA upon request. Copies of EA's will also be available for inspection during normal business hours at the Area Geothermal Supervisor's office, the District Geothermal Supervisor's office, Reno, Nevada and the BLM, Riverside, California, District Manager's office, and BLM, El Centro Resource Area office.

for Wright Sheldon

Enclosure

INTERESTED PARTIES EA #146-80

Republic Geothermal, Inc.
POO Exploration

CA-6217 & CA-6218
East Mesa, CA

* * * * *

District Geothermal Supervisor
USGS, Conservation Division
Kietzke Plaza, Bldg. D, Suite 137
4600 Kietzke
Reno, Nevada 89502
*FTS: 470-5676 Comm: 704-784-5676

Conservation Manager, Western Region
ATTN: Environmental Staff
USGS, Conservation Division
345 Middlefield Rd., MS 80
Menlo Park, California 94025
*FTS: 467-2108 Comm: 415-323-8111

Mr. Henry Cullins
Area Geologist, Pacific Area
USGS-Conservation Division
345 Middlefield Road, MS 80
Menlo Park, California 94025
*FTS: 467-2053 Comm: 415-323-8111

USGS-Subsidence Research
ATTN: Bruce L. Massey
Federal Building, Rm. W2528
2800 Cottage Way
Sacramento, California 95825
*FTS 468-4258

Dr. G. D. Robinson, Chairman
Geothermal Environmental Advisory Panel
345 Middlefield Road, MS 19
Menlo Park, California 94025
*FTS 467-2871 415-323-8111 X2871

Mr. Theodore W. Holland
U.S. Bureau of Land Management
550 W. Fort St., Box 042
Boise, Idaho 83724

California State Director
Bureau of Land Management
Federal Building, Room E-2841
2800 Cottage Way
Sacramento, California 95825
*FTS: 468-4676 Com (916) 484-4676

Riverside District Manager
Bureau of Land Management
1695 Spruce Street
Riverside, California 92507
ATTN: Gary Hillier, District Mgr
*FTS 796-1462 Com (714)787-1462

Bureau of Land Management
El Centro Resource Area
ATTN: David Mari
333 South Waterman
El Centro, California 92243
*FTS: 894-2451 Comm: 714-352-1812

U.S. Fish and Wildlife Service
ATTN: William D. Sweeney
2800 Cottage Way
Sacramento, California 95825
*FTS 468-4664 Comm: 916-484-4664

U. S. Fish and Wildlife Service
ATTN: Gail Kobetich
Endangered Species Office
2800 Cottage Way, Room E-2720
Sacramento, California 95825
*FTS: 468-4516 Comm: 916-484-4516

Bureau of Reclamation
P.O. Box 427
Boulder City, Nevada 89005
*FTS 598-7161 Comm: 702-293-2161

U.S.Environmental Protection Agcy.
Environmental Monitoring & Support Laboratory
ATTN: Michael O'Connell
P.O.Box 15027 Las Vegas, Nv 89114
*FTS: 595-2969 Comm: 702-736-2969

Department of Energy, Division of Geothermal Resource Management
ATTN: Mr. Fred H. Abel, Prog Mgr
20 Massachusetts Avenue, NW
Washington, D.C. 20545

Department of Energy, Geothermal
ATTN: Bennie DiBona
20 Massachusetts Avenue, NW
Washington, D.C. 20545
*FTS 376-1690 Comm: 202-376-1690

California Division of Oil & Gas
ATTN: Mr. Don Lande
Suite 309-N
5199 East Pacific Coast Highway
Long Beach, California 90804

INTERESTED PARTIES for EA #146-80

California Department of Fish & Game
ATTN: Don Lollock
1416 Ninth Street
Sacramento, California 95814
*FTS 465-1383 Comm: 916-455-1383

Native American Heritage Committee
ATTN: Stephen Rios
1400 10th Street
Sacramento, CA 95814
*916-322-7791

Imperial Irrigation District
Attn: Helen French
1285 Broadway
El Centro, California 92243
*(714-352-1991)

Ms. Elaine Hussey
Geothermal Office
California Energy Commission
1111 Howe Ave - Mail Stop 58
Sacramento, CA 95825
Tel 916-920-7329

State of California
Department of Parks & Recreation
ATTN: Knox Mellon, SHPO
P.O. Box 2390
Sacramento, California 95811

Governor's Office of Planning and Research - State Clearing House
ATTN: Bill Kirkham and Susan Brown
1400 Tenth Street
Sacramento, California 95814

State of California
Calif. Reg. Water Quality Board
Colorado River Basin Region
ATTN: Arthur Swajian
73271 Highway 111, Suite 21
Palm Desert, CA 92260

State of California
Water Resources Control Board
ATTN: Alvin Franks
P.O. Box 100
Sacramento, California 95801
*Comm: 916-445-2774

State of California
Public Utilities Commission
ATTN: Mr. William N. Foley
350 McAllister Street, Room 5069
San Francisco, California 94102

Imperial County Planning Board
Richard Mitchell-Planning Director
County Services Building
940 Main Street
El Centro, California 92243
*Comm: 714-352-8184

Lawrence Livermore Laboratory
Box 5507, Mail Code L-523
Livermore, California 94550
*FTS 532-1100 Comm: 415-422-1100

Earth Science Laboratory
Univ of Utah Research Institute
ATTN: Phillip M. Wright
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108
*Tel (801) 581-5283

Mr. Jay von Werlhof, Archaeologist
Imperial Valley College
Museum
442 Main Street
El Centro, California 92243

Geothermal Resources Council
Attn: Mr. David Anderson
P.O. Box 98
Davis, CA 95616
*Comm: 916-758-2360

Amax Exploration, Incorporated
ATTN: Mr. Larry Hall
7100 West 44th Avenue
Wheatridge, Colorado 80033
*FTS 234-3131 (303-420-8100)

Aminoil USA, Incorporated
ATTN: Mr. C. E. Woods
Post Office Box 11279
Santa Rosa, California 95406
*FTS Ope: 623-1011 707-527-5333/2

INTERESTED PARTIES for EA #146-80

Anadarko Production Company
ATTN: Mr. R. C. Edmiston
Post Office Box 1330
Houston, Texas 77001
*FTS Ope: 527-4011 713-526-5421

California Energy Company, Inc.
ATTN: Mr. Paul Storm
P.O. Box 3909
Santa Rosa, California 95402
*Comm: 707-526-1000

Chevron USA, Inc.
ATTN: J.G. Turner
Post Office Box 3722
San Francisco, California 94119
*Tel: (415) 894-2726

Energy and Natural Resources
Consultants
ATTN: Richard Jodry
Post Office Box 941
Richardson, Texas 75080
*214-238-9554

GeothermEx, Inc
Attn: James B. Koenig
901 Mendocino Avenue
Berkeley, California 94707
*Comm: 415-524-9242

Geothermal Power Corporation
ATTN: Mr. Frank Metcalfe
1127 Grant Avenue, Suite 6
P.O. Box 1186
Novato, Califonia 94947
*Comm: 415-897-7833

Getty Oil Company
ATTN: Mr. Dan W. Sparks
Post Office Box 5237
Bakersfield, California 93388
*Tel: (805) 399-2961

Magma Power Company
ATTN: Mr. Richard Foss
631 S. Witmer Street
Los Angeles, California 90017
*Tel: (213) 483-2285

Magma Electric Company
ATTN: Tom Hinrichs
Post Office Box 2082
Escondido, CA 92025
*Tel: (714) 743-7008

Occidental Geothermal, Inc.
ATTN: B.J. Wyant
5000 Stockdale Highway
Bakersfield, California 93309
*Tel: (805) 327-7351

Republic Geothermal, Incorporated
Northern California Office
ATTN: J. L. Sheidenberger
1011 College Avenue, Suite 220
Santa Rosa, California 95404
*Comm: 707-527-7755

Republic Geothermal, Incorporated
ATTN: Mr. Dwight Carey,
and Ms. Tawna Nicholas
Post Office Box 3388
Santa Fe Springs, California 90670
*Tel: (213) 945-3661

San Diego Gas and Electric Company
ATTN: Larry Grogan/J.M. Nugent
P.O. Box 1831
San Diego, California 92112
*(714-232-4252, Ext. 1715/1903

SAYWRIGHT Corporation
ATTN: Mr. Wayne L. Sayer
Post Office Box 229
Fairfield, California 94533
*Tel: 707-429-5777

Southland Royalty Company
ATTN: Jere Denton
1000 Fort Worth Club Tower
Fort Worth, Texas 76102
*FTS Ope: 334-3001 817-390-9200

Sunoco Energy Development Company
ATTN: Mr. John Williams
Suite 1500 -- Box 9
12700 Park Central Place
Dallas, Texas 75251
*FTS 729-4011 214-233-2600

INTERESTED PARTIES for EA #146-80

Thermal Power Company
ATTN: Mr. Richard Miller
601 California Street, Suite 1302
San Francisco, California 94108
*415-981-5700

VTN
Attn: Richard A. Hallett
2301 Campus Dr.
P.O. Box C-19529
Irvine, CA 92713
*Comm: 714-833-2450

Gulf Mineral Resources Company
Exploration Department
ATTN: Mr. Glen Campbell
1720 South Belaire Street
Denver, Colorado 80222
*FTS Ope: 327-0111 303-758-1700

Mr. Frederick Tornatore
c/o Atlantis Scientific
9015 Wilshire Blvd
Beverly Hills, California 90211

Union Oil Company of California
Geothermal Division
ATTN: Neil Stefanides
Union Oil Center, PO Box 7600
Los Angeles, California 90051
*213-486-7740

Phillips Petroleum Company
Geothermal Operations
ATTN: Bob Wright
Post Office Box 239
Salt Lake City, Utah 84110
*Comm: 801-364-2083

Mr. Clyde E. Kuhn
Cultural Resources Management, Inc
Post Office box 69
Davis, California 95616

REPUBLIC GEOTHERMAL, INC.
11823 EAST SLAUSON AVENUE, SUITE ONE
SANTA FE SPRINGS, CALIFORNIA 90670
(213) 945-3661

December 7, 1979

Area Geothermal Supervisor
U.S. Geological Survey
Conservation Division MS 92
345 Middlefield Road
Menlo Park, California 94025

Attention: Mr. David Bickmore

Please find enclosed three copies of our Plan of Operation, Exploration, for East Mesa Federal Geothermal Lease Nos. CA 6217 and CA 6218. This Plan is for nine deep exploratory wells on the two leases which Republic received in the most recent competitive lease sale. The road and well locations will soon be surveyed and staked, and arrangements are being made for a cultural resources survey. These wells will be drilled similar to wells previously drilled by Republic at East Mesa. Specific information required for a Geothermal Drilling Permit will be submitted at a later date.

We are looking toward approval of this Plan by mid-March 1980; your assistance in the timely evaluation and approval of the Plan would be greatly appreciated. Should you have any questions or concerns, please do not hesitate to call.

Respectfully,

Tawna J. Nicholas

Tawna J. Nicholas
Senior Enviornmental Planner

TJN/wp

PLAN OF OPERATION, EXPLORATION

Leases No. CA 6217 and CA 6218
Secs. 5 and 6, T16S, R17E; Secs. 31 and 32
T15S, R17E, SB B&M

Republic Geothermal, Inc.
11823 East Slauson Avenue, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

Proposal for nine exploratory deep resource well locations, and for each location: construct site and access roads, drill and complete well, conduct clean-out and initial flow tests, work-over well if necessary, and either construct production test facilities and place well on sustained production test, or convert to a temporary waste fluid disposal well and receive waste fluid from other production tests. East Mesa Well Nos. 14-5, 54-6, 14-31, 32-31, 38-31, 54-31, 78-31, 14-32 and 38-32.

Estimated Starting Date: March 15, 1980

Estimated Completion Date: Indefinite

REPUBLIC GEOTHERMAL, INC.

PLAN OF OPERATION, EXPLORATION
UNITED STATES GEOTHERMAL LEASE NOS. CA 6217 and CA 6218
EAST MESA, IMPERIAL COUNTY, CALIFORNIA

A. PROPOSED PLAN OF OPERATION

Republic Geothermal, Inc. proposes to commence geothermal exploration operations on Lease Nos. CA 6217 and CA 6218. Republic proposes nine exploratory deep resource wells to be located within the above lease areas; all will be vertical holes on new well pads. These well sites, on leases which Republic received by competitive bidding in May 1979, are necessary to define the limits and commercial potential of the geothermal resource.

The following sequence of operations would occur when drilling an exploratory well at any of the proposed sites:

1) Construct drilling location site and required access roads, if any.

2) Drill and complete the well, including clean-out flows and initial testing to the storage basin.

3) After analysis of the log and test data, workover well if required.

4) Continue initial testing; data analysis and workover until well demonstrates satisfactory commercial potential.

5) Construct temporary production test facilities, including waste fluid disposal pipeline to an approved temporary waste disposal well or approved injection well.

6) Place well on sustained production test.

7) If well does not demonstrate satisfactory commercial potential, possibly workover well and convert to temporary waste disposal well.

8) Utilize converted well for temporary waste disposal.

Republic recognizes that, prior to commencing any of the above-mentioned operations, specific details of the proposed operation must be submitted to the Area Geothermal Supervisor and explicit approval obtained.

B. DETAILS OF PROPOSED PLAN

1. Location and Placement of Proposed Operations

The approximate location and elevation of the nine exploratory deep resource well locations are as follows:

Well No.	Location	Ground Elevation
14-5	T16S, R17E, 345'E & 2880'N from SW cor. Sec. 5	53'±
54-6	T16S, R17E, 2740'E & 2880'N from SW cor. Sec. 6	38'±
14-31	T15S, R17E, 175'E & 2880'N from SW cor. Sec. 31	30'±
32-31	T15S, R17E, 1420'E & 4200'N from SW cor. Sec. 31	35'±
38-31	T15S, R17E, 1420'E & 240'N from SW cor. Sec. 31	32'±
54-31	T15S, R17E, 2740'E & 2880'N from SW cor. Sec. 31	40'±
78-31	T15S, R17E, 4060'E & 240'N from SW cor. Sec. 31	45'±
14-32	T15S, R17E, 325'E & 2880'N. from SW cor. Sec. 32	55'±
38-32	T15S, R17E, 1420'E & 240'S from SW cor. Sec. 32	70'±

Attached is our Drawing No. 199-10A, East Mesa Geothermal Project, Vicinity Map and Exploration Plan, which shows the topography, drainage patterns, cultural features, existing and proposed roads and wells, lands reserved by the U.S. Department of Energy and lands where no surface occupancy will be permitted until the BLM approves an area-wide management plan for cultural resources.

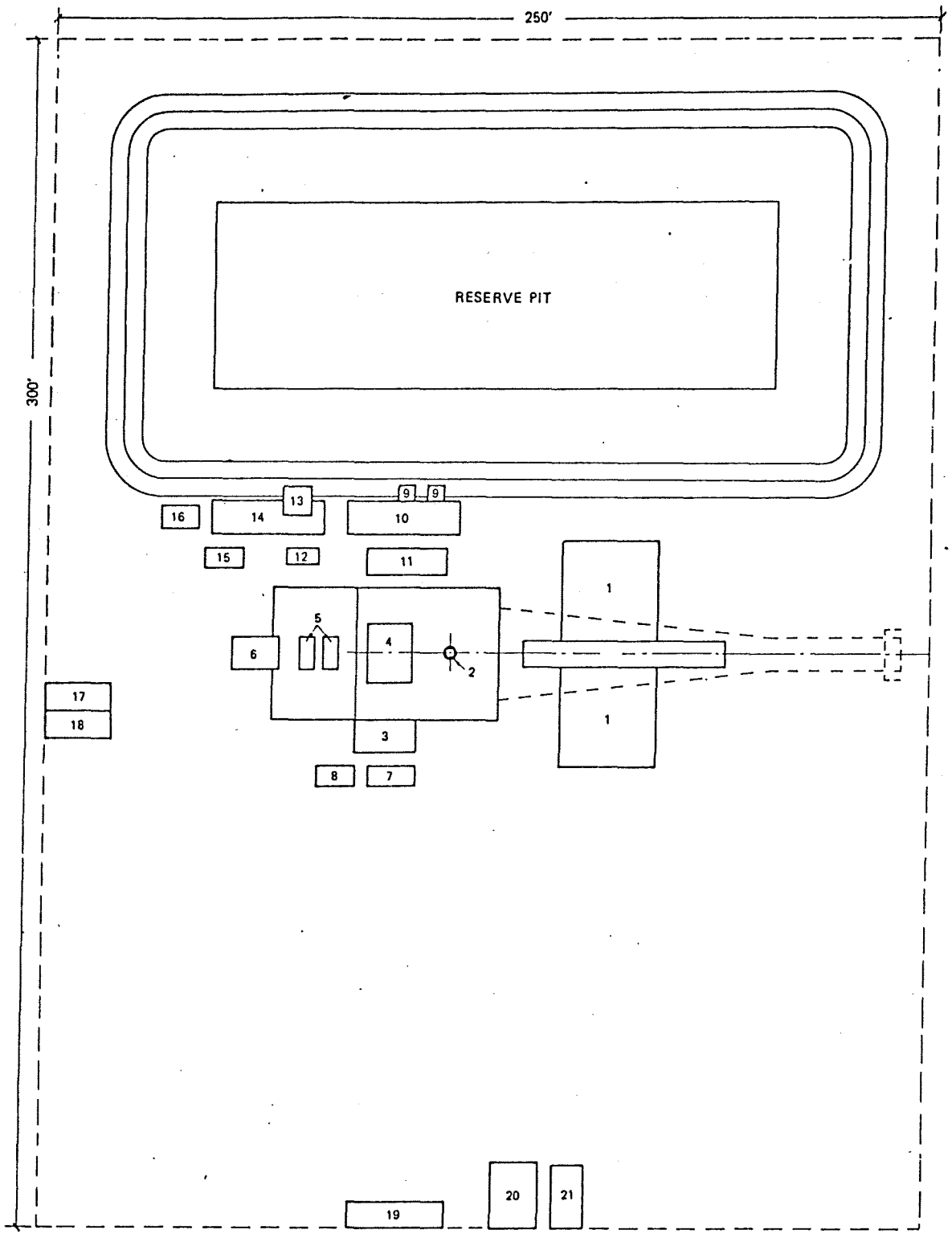
Figure 1 shows a typical site plan for a geothermal resource well drill site, including a layout showing the position of mud tanks, reserve pits, cooling towers, pipe racks, etc.

2. Discussion of Proposed Operations

The purpose of this exploratory program is to define the limits and commercial potential of the geothermal resource on lands which were previously administered by the U.S. Bureau of Reclamation and Department of Energy. The proposed new well locations have been chosen to be compatible with alternatives being considered in long-range planning for all five leases which are held by Republic at East Mesa. The road system similarly is anticipated to be used not only during drilling of these proposed wells, but also during production testing and any subsequent drilling or development operations. It has been designed to disturb the least amount of surface possible for the efficient utilization of the anticipated geothermal resources at East Mesa. Wells have been located wherever possible on existing access roads. Republic is proposing an additional one and three-quarter miles of new access roads for this nine well program. Once the location site and access roads are completed for any well, there will be no additional land surface disturbed during drilling, testing, workover, production testing or conversion operations.

Republic may not drill all nine proposed wells under this Plan of Operation, Exploration. Approval of all well locations is requested for flexibility in well siting. The decision of which wells will be drilled will be made after the data from the previous well has been analyzed. The drilling program for these wells will be similar to those used for wells previously drilled by Republic at East Mesa. Specific information required for a Geothermal Drilling Permit will be submitted at a later date. All surface work will be performed on a well-by-well basis, as necessary.

Subsequent to drilling and completion, each well will be flowed into the storage basin to clean out drilling fluids and formation sands. Initial flow tests will also be made into the storage basin. Should these initial tests show the well to be of less than commercial value, appropriate workover procedures will be undertaken, with the concurrence and approval of the Area Geothermal



1 PIPE RACKS
2 WELL POINT
3 DOG HOUSE
4 DRAWWORKS
5 ENGINES
6 MUD PUMP
7 B.O.P.E.
8 LIGHT PLANT
9 SHAKER BOX
10 MUD TANK
11 WATER
12 CIRCULATION PUMP
13 DESANDER
14 MUD TANK
15 COOLING TOWER
16 STAND-BY PUMP
17 CHANGE HOUSE
18 STORAGE
19 TRAILER
20 FUEL TANK
21 TRASH BIN

Figure 1 Typical site plan for East Mesa geothermal exploratory resource drill site

Supervisor, and the well re-tested into the basin until satisfactory commercial potential is achieved. Should the well be determined to be of less than commercial potential after retesting, the well may be converted, with the concurrence and approval of the Area Geothermal Supervisor, to a temporary waste disposal well to receive fluids from sustained production tests from other wells.

Should the well prove to be of satisfactory commercial potential, Republic will construct temporary facilities for sustained production testing. All production testing facilities will be constructed on previously cleared land. This includes the approximately 10-inch temporary waste-fluid disposal line, which will be located along and within the previously constructed access roads connecting the producing well and the temporary waste-fluid disposal well. Waste fluids produced as a result of production testing may be disposed, with the concurrence and approval of the Area Geothermal Supervisor, into the previously completed and approved intervals of East Mesa Well Nos. 18-28, 52-29 or 56-19, or with the concurrence and approval of the Area Geothermal Supervisor, into the zones or intervals of any other well drilled or converted for injection or temporary waste fluid disposal.

3. Source of Water Supply and Road Building Material

In accordance with Section 270.34, water for operations will be supplied by the previously approved WW-1, a shallow water well located in the northwest corner of Republic's East Mesa maintanance yard.

No road building material will be obtained from federal lands. If road building material such as gravel is needed, it will be trucked from outside commercial sources.

4. Additional Information

The following, submitted by Republic Geothermal to the Area Geothermal Supervisor, are incorporated herein and made a part hereof by reference:

a) Plan of Operation, approved as effective September 12, 1975 (EA 12).

b) Supplemental Plan of Operation, approved as effective December 15, 1975 (EA 29).

c) Plan of Operation, approved as effective December 1, 1976 (EA 61).

d) Supplemental Plan of Operation, approved as effective September 16, 1977 (EA 81).

e) Amended Plan of Operation, approved as effective January 17, 1978 (EA 86).

f) Program for Collection of Environmental Baseline Data, Federal Geothermal Leases CA 966, CA 967, and CA 1903, submitted August 31, 1977.

g) Plan of Operation, Development (10 Mw Power Plant) approved as effective September 13, 1978. (EA 99-100).

h) Plan of Operation, Injection (10 Mw Power Plant), approved as effective September 13, 1978. (EA 99-100).

i) Plan of Utilization (10 Mw Power Plant) approved as effective September 13, 1978. (EA 99-100).

j) Plan of Operation, Development (48 Mw Power Plant), approved as effectiv July 20, 1979 (EA 107-9).

k) Plan of Operation, Injection (48 Mw Power Plant), approved as effective July 20, 1979 (EA 107-9).

l) Plan of Utilization (48 Mw Power Plant) approved as effective July 20, 1979 (EA 107-9).

C. ENVIRONMENTAL PROTECTION

The following measures will be taken for protection of the environment:

1. Fire

All local, state and federal fire protection standards applicable to Republic's activities will be observed. Vegetation on the lease is sparse and low-level and will be cleared only to the extent needed for proper operation. Smoking will be allowed only in designated areas. Water and fire extinguishers will be available at each site during drilling activities and at a central location during testing and construction activities in the unlikely event a fire should occur.

2. Soil Erosion

Due to the essentially level topography at East Mesa, the infrequent rainfall and the lack of surface water, soil erosion is not anticipated to be a problem. Well location sites, surface facilities and access roads are designed to disturb only the minimum amount of surface necessary for efficient operation. Off-road vehicle use will be prohibited except where necessary. Best efforts will be made to minimize disturbance of the perennial woody vegetation. For the proposed wells, those portions of the well pad required for the proposed production tests will be covered with gravel to prevent erosion and cleared areas not required after drilling will be allowed to revegetate naturally.

3. Pollution of the Surface and Ground Water

a. Surface Water

Surface waters within Republic's East Mesa leasehold are limited to one very short section of the East Highline Canal on the southwestern boundary of Lease No. 6218. The remainder of the area is devoid of obvious stream channels.

The low salinity of the geothermal fluids produced from Republic's East Mesa wells, lease stipulations which restrict drilling within one-quarter mile of the canal, and the distance to the nearest well proposed under this Plan of Operation from the canal all indicate that the proposed development will have no deleterious effect on the quality of water in the East Highline Canal.

b. Ground Water

There are no natural ground water sources such as springs or seeps within Republic's East Mesa leases. The California Regional Water Quality Control Board considers the ground water in the vicinity of Republic's leases saline and not beneficially used.

All of Republic's previously approved Plans of Operation on East Mesa have been conducted under approved Orders No. 76-35 and No. 76-64 (Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region. These Orders have been previously submitted to the USGS-AGS. They do not include the wells proposed under this Plan of Exploration, but they are an example of what is likely to be required for the proposed operations.

The Board has determined in the previous orders that Republic's discharge of geothermal fluids into unlined temporary storage basins is acceptable for fluids with less than 2,300 mg/l of total dissolved solids (TDS). They have approved the discharge of geothermal fluids onto roads and well sites in an amount not to exceed 126,000 gallons per day or 232 acre-feet for the life of the project. This Order also permits the disposal of geothermal waste fluids by subsurface injection into the zone of extraction or into zones which contain a total dissolved solids content that is equal to or greater than that contained in the zone of extraction.

Republic will also protect the area's ground water by complying with the provisions of GRO Order No. 2 or exceptions to this Order as approved by the Area Geothermal Supervisor for East Mesa. Drilling muds will contain no toxic materials or materials which could contaminate the ground water. All pipelines will be properly constructed and maintained to prevent leakage.

4. Fish and Wildlife

There are no fish in the area. The construction of the proposed well pads and roads will result in some unavoidable permanent destruction of habitat. The proposed production and injection testing will not disturb additional habitat. Construction of the proposed pipelines will result in temporary surface disturbance of approximately five feet along one side of the approved and existing access roads. No other surface disturbance is anticipated.

Because of the minor amount of habitat disturbance and the homogeneous nature of the vegetation at East Mesa, it is anticipated that this disturbance will not significantly impact the area's wildlife. To help provide replacement habitat, removed vegetation and excess soil shall be stacked in several piles at a reasonable distance from the roads and drillsites.

5. Air and Noise Pollution

a. Air

Air quality should not be significantly degraded during these proposed operations. All operations will be conducted with the approval of the Imperial County Air Pollution Control District. To date, the concentration of the noncondensable gases in the wells drilled at East Mesa has been less than 0.1% by weight of total produced fluids, and only minute concentrations of hydrogen sulfide have been detected. Because the concentration of these gases is so low and there are no known deleterious constituents in quantities harmful to the environment, Republic

does not anticipate that the proposed operations at East Mesa will significantly degrade the existing ambient air quality.

Dust from cleared roads and drillsites shall be suppressed by distribution of geothermal fluids on these areas, as evaluated and approved by the California Regional Water Quality Control Board.

b. Noise

Noise is expected to be of minor concern. Noise levels will be maintained within the limits prescribed by Imperial County, the Bureau of Land Management and the Occupational Safety and Health Administration. Drilling rig engines and compressors will be equipped with mufflers.

Noise impacts on wildlife at East Mesa will probably be minimal because of the relatively low intensity and steady, continuous nature of most of these noise emissions. The East Mesa area itself is also very isolated from any human receptors. The extant ambient noise levels on East Mesa are usually very low, but are frequently punctuated by the sounds of aircraft overflights and explosions from the nearby military gunnery range. Occasional off-road vehicle use of the area also adds to the ambient noise levels.

6. Hazards to Public Health and Safety

Public health and safety shall be ensured through the use of appropriate equipment, operating procedures and notices. Appropriate warning signs will be posted before curves on the access roads and on all pipelines and testing equipment. Each well will be posted with a sign indicating the well name, the designated operator and an emergency phone number. Supervisory personnel will be on-site during drilling and testing operations.

Wells will be chained and locked when unattended. All drilling shall be conducted in accordance with all state and federal requirements, specifically GRO Order No. 2.

7. Section 270.34 (i) and (j)

a. Methods for Disposal of Waste Material

Waste waters will be disposed of as indicated in Part 3.b. above. Portable chemical sanitary facilities will be used by personnel on the drilling or construction sites. These will be maintained and wastes disposed of by a local contractor.

The site will be kept clean and any trash or debris will be taken to an approved dump. Drilling muds may be neutralized and used as a binder in construction of new roads and well pads. The remaining drilling muds will be disposed of in a suitable waste disposal site as determined by the California Regional Water Quality Control Board.

b. Delineation of Potential Environmental Impacts

Republic anticipates that there should be only negligible environmental impacts from these proposed operations over and above those from existing approved operations.

c. Environmental Monitoring and Any Additional Information

Noncondensable gases will be monitored in accordance with the requirements of the Imperial County Air Pollution Control District.

Geothermal fluids will be monitored and disposed of in accordance with the requirements of Orders Nos. 76-35 and 76-64(Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region, or in accordance with any subsequent Orders which may be issued by the CRWQCB for these wells.

Republic has submitted to the Supervisor a Program for Collection of Environmental Baseline Data for Federal Geothermal Leases CA 966, CA 967, and CA 1903 at East Mesa, in accordance with 270.34 (k).

Republic is prepared to submit, upon notification to do so, any further information not included herein which the Supervisor may require. Republic is also prepared to carry out provisions for monitoring deemed necessary by the Supervisor to ensure compliance with the regulations and to participate in the collection of data concerning the existing air and water quality, noise, seismic and land subsidence activities, and ecological systems in the vicinity of the site.

d. Approximate Crew Size, Probable Type and Location of Housing and Support Facilities

Approximately twelve to fifteen people may be working on the location at any one time during drilling and/or production testing operations. No housing or special support facilities will be required on-site during these operations due to proximity of existing facilities.

D. ENVIRONMENTAL CONCERNS

The BLM has identified several areas of the leased lands where significant cultural resources may be present. Under lease stipulations, no surface occupancy may be permitted on those lands, shown in Exhibit A, Drawing No. 199-10A, until the BLM accepts an area-wide management plan for cultural resources. The plan is currently nearing completion. None of the well sites or access roads proposed in this Plan are located in the sensitive areas. Republic will work with a qualified archaeologist for cultural resource surveys of lands within the area of operations of this Plan, and with the BLM for the development of the management plan.

E. EMERGENCY CONTINGENCY PLAN

If any emergency develops or is determined to be impending, appropriate control procedures will be initiated. The specific procedures will vary greatly depending on the nature of the problem. Examples of possible emergencies are: a well control problem (well blowing steam, hot water or other well effluent with loss of means to shut-in or divert the flow); a spill of geothermal fluid; fire; accidents or injuries; etc. The following measures will be taken:

1. If any injuries have occurred, arrangements will be made to care for the injured party(ies).

   Cal-Com Service Corporation
   496 W. Euclid Road
   El Centro, California 92243
   (714) 352-4434

   First aid supplies will be available at the drillsite during drilling operations as well as at the East Mesa office during all other operations. At least one person on each crew will be trained in first aid.

2. If there is a threat to local residents, the Sheriff will be notified as soon as possible.

   Imperial County Sheriff's Department
   150 S. 9th
   El Centro, California 92243
   (714) 352-3111

3. The Field Production Superintendent will be notified and consulted immediately.

   Carl E. Fisher
   El Centro, California 92243
   (714) 352-3111
   Home: (714) 353-3544

4. Field supervisory personnel will contact the Senior Operations Engineer(s) and consult with him as to any further or supplemental steps which may be necessary or advisable.

   Thomas A. Turner
   Senior Operations Engineer
   11823 E. Slauson Ave., Suite One
   Santa Fe Springs, California 90670
   (213) 945-3661 - Office
   (213) 855-0630 - Home

B. A. "Chip" Gillette
Senior Operations Engineer
11823 E. Slauson Ave., Suite One
Santa Fe Springs, California 90670
(213) 945-3661 - Office
(714) 963-8662 - Home

5. The Senior Operations Engineer will:

(a) Brief his immediate supervisor on the situation and course of action underway.

Tom L. Cook, Jr.
Vice President, Operations
11823 E. Slauson Ave., Suite One
Santa Fe Springs, California 90670
(213) 945-3661

(b) Contact the following agencies or regulatory bodies as soon as practicable and in the following order:

U. S. Geological Survey
District Geothermal Supervisor
4600 Kietzke Lane
Building D, Suite 137
Reno, Nevada 89502
USGS - (702) 784-5676
Mr. Bernie Moroz
Home - (702) 826-8780
Mr. Doug Koza
Home - (702) 851-0987

U. S. Geological Survey
Area Geothermal Supervisor
Conservation Division
Western Region
345 Middlefield Road
Menlo Park, CA 94025
(415) 323-8111, Ext. 2845
Night line (415) 323-1164
Mr. David Bickmore
Home - (408) 238-7359
Mr. Ellis Hammett
Home - (415) 328-8679

Bureau of Land Management
1695 Spruce Street
Riverside, California 92502
(714) 787-1649
Mr. Roger Haskins

(c) If the emergency involves a well control problem or other well operation, he will also notify the following agency:

Department of Conservation
State of California
Division of Oil and Gas
Geothermal Unit
1416 Ninth Street
Sacramento, California 95814
(916) 445-9687

6. All prescribed safety practices and procedures will be followed. All members of the drilling, well testing, construction or field operations crews will perform duties assigned for the specific purpose, following specified safety practices and procedures.

7. Every effort will be made to minimize possible deleterious environmental effects of the emergency and the operations performed to control the emergency.

8. A pump truck will be in the vicinity, and earth moving equipment may be obtained from local contractors, if necessary.

Wendell Transport Company
Imperial, California 92251
(714) 355-4355
(714) 355-2125

Ryerson Ditch-Liners
50 East Highway 80
El Centro, California 92243
(714) 352-4341

Merrill Ditch-Liners, Inc.
51 East Highway 80
El Centro, California 92243
(714) 353-0193

9. The Vice President, Land, will be advised and consulted as soon as practicable. He may consult with Republic's environmental staff.

Timothy M. Evans
Vice President, Land
11823 E. Slauson Ave., Suite One
Santa Fe Springs, California 90670
(213) 945-3661 - Office

10. The Vice President, Land, or Republic's environmental personnel will notify as soon as possible the following additional state and local agencies as necessary:

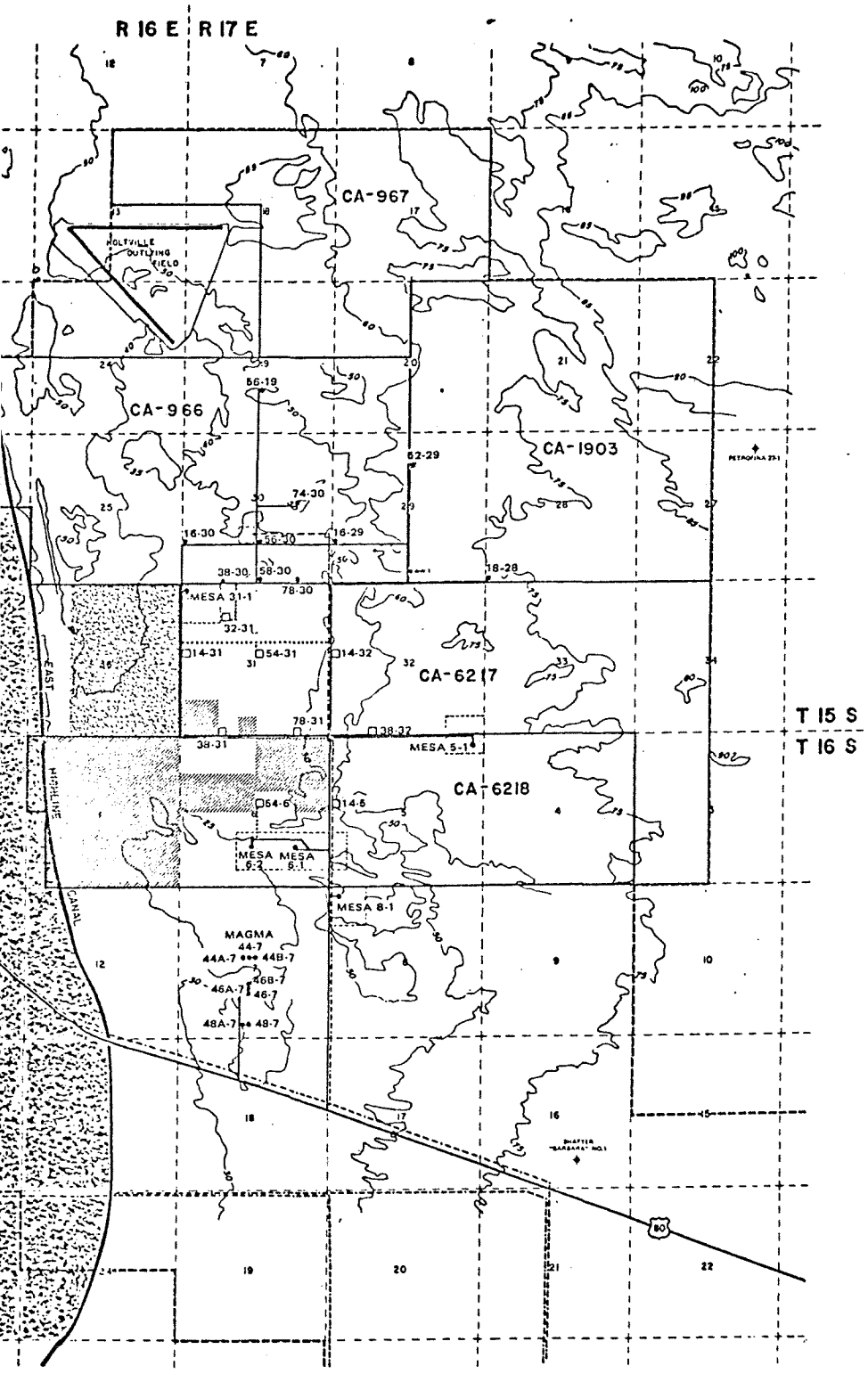
California Regional Water
Quality Control Broad
Colorado River Basin Region
73-271 Highway 111
Suite 21
Palm Desert, California 92260
(714) 346-7491

Imperial County Air Pollution
Control District
El Centro, California 92243
(714) 352-3610

Imperial County Planning
Department
El Centro, California 92243
(714) 352-8184

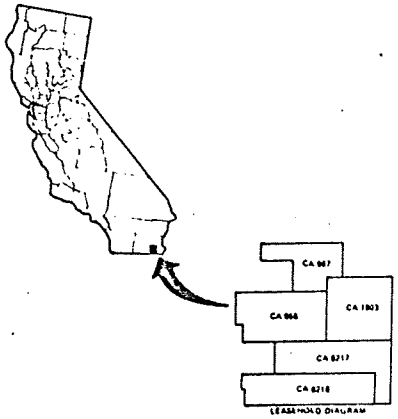
Resources Agency
State of California
Department of Fish and Game
Region No. 5
350 Golden Shore
Long Beach, California 90802
(213) 435-7741

U. S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, California 95825
(916) 484-4657



LEGEND

- EAST MESA K.G.R.A. BOUNDARY
- LEASEHOLD BOUNDARY
- PRODUCTION WELL
- INJECTION WELL
- ABANDONED WELL
- ROAD, IMPROVED SURFACE
- ROAD, UNIMPROVED SURFACE
- LANDS RESERVED BY DEPARTMENT OF ENERGY
- ORANGE GROVE
- AGRICULTURAL CULTIVATION
- EXISTING WATER WELL
- EXISTING ELEC. TRANSMISSION LINE
- APPROVED PROPOSED POWER PLANT SITE
- PROPOSED WELLS
- PROPOSED ROADS
- CULTURAL RESOURCE "NO SURFACE OCCUPANCY" AREAS



LEASEHOLD DIAGRAM

EXHIBIT A

EAST MESA
GEOTHERMAL PROJECT VICINITY MAP
EXPLORATION PLAN