

PLAN OF OPERATION
EXPLORATION/DRILLING

Lease Number CA-959
Section 29 & 33, T11N, R8W, MDB&M
Lease Number CA-5639
Sections 27, 28, 29, 32, and 33, T11N, R8W, MDB&M
Lease Number CA-5640
Section 5, T10N, R8W, MDB&M
Section 29, T11N, R8W, MDB&M

Big Geysers, Sonoma County, California

UNION OIL COMPANY OF CALIFORNIA
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This plan proposes the improvement of existing roads, the construction of new roads, the construction of multiple-well drilling sites and the drilling and testing of exploratory wells in the above leases. The plan is submitted as a multiple-well program to facilitate and expedite the processing, approval and execution of future Plans and Permits. The plan as presented thus has the flexibility necessary to determine the existence, extent, characteristics and performance of the suspected geothermal resource.

Estimated Starting Date: August 15, 1979

Estimated Completion Date: Unknown

UNION OIL COMPANY OF CALIFORNIA
PLAN OF EXPLORATION OPERATION/DRILLING

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UNION OIL COMPANY OF CALIFORNIA
PLAN OF EXPLORATION OPERATION

UNITED STATES GEOTHERMAL LEASES
CA-959, CA-5639 & CA-5640
BIG GEYSERS, SONOMA COUNTY, CALIFORNIA

A. INTRODUCTION

Union Oil Company of California proposes to conduct an exploratory drilling program on federal lands and federal mineral reserve lands in the southeast Geysers area. The leases to be explored are CA-959, CA-5639 and CA-5640 totaling approximately 1260 acres. The Plan of Exploration proposes improvement of existing roads, construction of new roads, construction of up to ten drilling locations and drilling and testing enough wells to prove up steam reserves on about 60% of those lands. Our present goal is to locate and establish steam reserves for a 110 MW electrical generating plant. If the proposed exploratory project is successful, we will submit the subsequent plans of operation required for review of the proposed operations and expected environmental impacts associated with development and utilization of the resource.

B. DETAILS OF THE PLAN OF EXPLORATION OPERATION

1. Location Description

Attached hereto and made a part hereof is Exhibit A Maps. Map A-1 is a vicinity map showing the lease area with respect to The Geysers and surrounding areas. Map A-2 is a topographical map, scale 1000'=1", on which the following are shown: lease boundaries and lease numbers, the location of all existing and abandoned wells, all existing, improved existing, and planned access roads, topographic features, drainage patterns and the water supply location. In addition, map A-2 shows the proposed locations of the following 10 exploratory well pads: two-well pad 14-27, A; four-well pad 16-29, A,B,C; three-well pad 66-30, A,B; four-well pad 71-31, A,B,C; three-well pad 52-32, A,B; three-well pad 81-32, A,B; three-well pad 85-32, A,B; and four-well pad 42-33, A,B,C.

2. Site and Access Selection Preparation

a. General Discussion

Per listed criteria in Draft GRO No. 5 2.E (1) (a)-(g) the proposed well pad sites are spaced such that optimum resource information can be obtained with a minimum number of wells.

Attached hereto and made a part hereof is Exhibit B: "Earthwork and Construction Specifications." Exhibit B contains the specifications for drill site and road construction at Union Oil Company's drill sites at The Geysers geothermal area. Included in Exhibit B are engineering drawings for typical road construction, and a typical drilling pad layout.

b. Geologic Description

The following is a general geological description of the subject federal lease areas. Specific geologic descriptions of the proposed well locations are presented in Exhibit C attached hereto and made a part hereof.

The federal leases CA-959, CA-5639 and CA-5640 are underlain by Franciscan formation rocks. The formation is composed mainly of graywacke and greenstone (altered basic volcanic rocks) with intrusive serpentinite and minor amounts of chert, conglomerate and various high grade metamorphic rocks. The structural grain of the

Franciscan formation is generally northwest trending. An unusual characteristic of the formation is the high degree of tectonic deformation to which it has been subjected. The graywackes, cherts, conglomerates, greenstones and metamorphics are generally closely fractured and moderately sheared while the softer shales and serpentinites are usually crushed and more highly sheared.

All three federal mineral right parcels are in the southeastern portion of The Geysers adjacent to our proposed Unit 18 development area. The geology of the Unit 18 area is described in detail in a confidential report by Union Geothermal entitled "Engineering Geology and Recommendation for Proposed Unit 18 Development Area." Since a portion of the subject exploratory area was covered during the above investigation, a copy of the report is forwarded with this Plan of Exploration Operation.

The federal leases in the undescribed portion of the above report are on the northeast flank of a major ridge which lies southwest and adjacent to Big Sulphur Creek. The geologic rock units of the Franciscan formation which underlies this portion of the ridge are generally northwest trending and parallel to the ridge and Big Sulphur Creek. A serpentinite unit occurs on the ridge crest. Immediately downslope of the serpentinite to about two-thirds of the distance to Big Sulphur Creek, the ridge is underlain by a graywacke with subordinate shale unit. The lower one-third of the ridge to Big Sulphur Creek is mainly underlain by a greenstone unit.

Major fault zones underlying portions of the federal leases southwest of Big Sulphur Creek include the Mercuryville fault along the ridge crest and an unnamed fault separating most of the predominantly graywacke and greenstone units between the ridge crest and Big Sulphur Creek. The Mercuryville fault zone is northwest trending and steeply dipping to the northeast. Serpentinite with varying thickness has been intruded along the fault zone and has been locally hydrothermally altered along its margins to silica-carbonate rock, the host rock for the area's mercury deposits. The unnamed fault lying between the graywacke and greenstone units is also northwest trending and, in at least one locality, dips about 75 degrees to the northeast. Both faults are apparently ancient inactive faults.

U.S. Geological Survey data presenting micro-earthquake epicenters at The Geysers indicate few, if any, of the hundreds of small earthquakes at The Geysers are along these two faults.

Several landslides occur on federal leases in this area in addition to those shown on the Unit 18 area map. They mainly head in the upper portion of graywacke near the Mercuryville fault zone and serpentinite unit. The landslides vary in size from large earth-rock debris flows with lengths exceeding 1500 feet and estimated thickness in excess of 100 feet to small rotational slumps. A large majority of the landslides are ancient and inactive with estimated ages in excess of 10,000 years. Only a few of the larger land slides show evidence of being recently active.

c. Hydrologic Description

Essentially, all drainage of the federal leases is to Big Sulphur Creek.

The subject leases are mainly on the northeast slope of a major ridge. The drainage consists of several parallel intermittent streams with lengths of about one mile. Stream gradients are an average of 2000 feet per mile. Drainage of the northwest side of Big Sulphur Creek in the vicinity of the federal leases is mainly by Little Geysers Creek and an unnamed stream which discharges by the well site proposed for federal well numbers 65-29, A and B. Little Geysers Creek is a perennial stream while the other stream is intermittent. Stream gradients of both streams are much less than the tributaries draining the federal leases on the north side of Big Sulphur Creek.

Meager data is available on near-surface groundwater conditions. Similar Franciscan formation, graywacke, greenstone and serpentinite rock units like those beneath the federal leases are known to yield very little usable groundwater in other areas. Water yields to wells are among the lowest of the geologic formations in the state and the formation is classified in both the California Department of Water Resources and U.S. Geological Survey publications as being essentially non-water-bearing. Near surface groundwater in these rocks is contained in and transmitted almost entirely through fracture systems, with little interstitial storage or

movement of water.

Exploratory foundation drilling by Union Geothermal and Harding Lawsen Associates and data developed by detailed geologic mapping indicates that most of the near surface groundwater is contained and transmitted through surficial landslides.

3. Drilling Program

The wells will be drilled with a rotary drilling rig such as those used in the oil industry. It will be equipped with diesel electric generators, storage tanks, mud pumps, other normal auxiliary equipment and geothermal modifications such as diesel driven air compressors. Total diesel consumption will be about 6.8 cubic meters (1800 gallons) per day.

The drilling program involves drilling a hole to the reservoir formation including the setting and cementing of surface and intermediate casings. This part of the hole is drilled using a clay-water drilling mud to circulate the rock cuttings to the surface where they are removed by screens and the mud is recirculated.

Pressures within the vapor-dominated reservoir at The Geysers are sub-hydrostatic and will not support the weight of drilling mud so the drilling into the reservoir utilizes compressed air to circulate the cuttings to the surface. The air, cuttings and any steam encountered are diverted through the blowie line to a cyclone separator/muffler. Water is injected into the blowie line to aid in removal of particulates from steam and air.

4. Completion and Testing

Normally, the wells will be completed open-hole in the production zone with a continuous string of production casing from the top of the production zone to surface.

After completion the wells will be put on vents large enough to prevent wellbore loading and mechanical damage. Vent size is reduced to 1/4" as practicable, at which vent rate is approximately 227 kg/hr (550 lb/hr).

Tests to provide data for the reservoir evaluation will consist of flow periods up to four days at various rates averaging less than 50,000 kg/hr. The steam will be flowed to the atmosphere through a muffler. All equipment, valves, flanges, and fittings shall meet minimum ASA or API standard specifications.

C. ENVIRONMENTAL CONCERNS

1. Methods for Disposal of Waste Materials

- A. All drilling mud wastes will be disposed of in the mud sump. As described in Section 7 of Exhibit B, the sump will be constructed to the requirements of a Class II-1 disposal site. The lining of the sump will be relatively impervious with a maximum permeability of 1×10^{-6} centimeters per second. The sump shall be abandoned upon completion of drilling operation at the drill site in strict accordance with Section 7.3 of Exhibit B, which is in accordance with requirements of the California Regional Water Quality Board, North Coast Region.
- b. Solid waste materials such as used in paper containers and towels, cardboard containers, metal strapping, etc. will be removed and disposed of by Union Oil at a certified public dump.
- c. 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 Union's field office.

2. Delineation of Potential Environmental Impacts

a. Physical Characteristics

Geological Hazards - Potential impacts and their mitigating measures are discussed with respect to seismicity induced by production of geothermal fluids, slope stability, and well blowouts.

Seismicity - No active faults are recognized or suspected in the lease area. The nearest known active fault in the region is the Healdsburg fault, which trends north-west through the Healdsburg area. The October 1, 1969 earthquake at Santa Rosa appears to have had its epicenter along the fault. Although that earthquake was felt at The Geysers, there were no damages caused by it.

A report by E. Majer and T. V. McEvilly, "Seismological Investigations at The Geysers Geothermal Field," Lawrence Berkeley Laboratory, U.C.B., December, 1977, concluded the following:

- a. Microearthquakes occur in a diffuse pattern in

the geothermal field.

b. It is possible that microearthquake activity is related to an expanding steam zone.

A more recent report describing results of the seismic detection network installed and maintained by the U.S. Geological Survey at The Geysers is presented in Open-File Report 78-798 by Marks, Ludwin, Louie, Bufe, et al. Plate I of this report depicts only one incident of microearthquake activity (in the SE 1/4 of the NE 1/4 of Section 29, T11, R8W, MDB&M) of magnitude less than 2.0. This is in marked contrast to the distinct clusters of microearthquakes occurring in some of the producing areas. Marks et al conclude that the present level of seismicity at The Geysers appears to be higher than the preproduction level and is higher and more continuous than the seismicity in the surrounding region. However, the report also concludes that The Geysers' earthquakes resemble those in the surrounding region in most characteristics including magnitude distribution, and that subtle differences in characteristics will have to be resolved by analysis of additional data.

Land Subsidence - Mr. Ben E. Lofgren, formerly of the U.S. Geological Survey, has conducted vertical and horizontal first order surveys over the Clear Lake-Geysers KGRA since 1973. His latest report, open file paper #78-597, shows that cumulative subsidence in the prospective lease areas (CA-959, CA-5639, CA-5640) has been about 0-1.3 cm (0 to 0.5 in) from 1973-1977 when referenced to Benchmark R 1243, which itself has subsided 5.56 cm (2.19 in) from 1973 to 1977. Lofgren maintains that subsidence is occurring at the rate of 2 cm (0.8 in) per year between the Collayomi and Mercuryville fault zones. Lofgren concludes that the compressive subsidence in the central production area does not appear to have any environmental implications at present. This would imply that exploratory drilling, testing, and production of wells in the prospective lease areas would not have appreciable environmental impacts. Rather, earth movements due to landslides, down slope creep, regional and local tectonism, and temperature changes are probably of greater magnitude and importance. (Lofgren, 1973)

Site Stability - Exhibit C is a discussion of the individual well site locations and roads with respect to potential site stability problems.

Additionally, Exhibit B, Earthwork and Construction Specifications, details the construction methods that will be used in building the proposed sites and roads. It is felt that the application of these methods to the specific locations will effectively mitigate or prevent any site stability problems.

Soils - Impacts of the proposed plans on the soils would be primarily from grading and compaction. Vegetative removal and soil mantle disturbance could lead to accelerated erosion.

The exercise of good engineering practices for earthwork, drainage and erosion control, preparation of drill site pad and road surfaces, as detailed in Section 3, 4 and 6 of Exhibit B, attached hereto, should satisfactorily prevent or mitigate soil erosion of the leasehold.

Air Quality - The potential impacts of the proposed operations are (1) increased suspended particulates from road construction, vegetation removal, and vehicular traffic, (2) particulates generated during air drilling, and (3) production of hydrogen sulfide (H_2S) during drilling and testing. The particulates from construction activities will be mitigated by the exercise of good engineering practices as outlined in Exhibit B, and by the wetting of problem dusty areas when necessary. Particulates generated from drilling will be abated by use of injected water and a cyclone separator/muffler, as detailed in part D 5 of this report. Potential impacts from the production of H_2S will be mitigated as required by the Northern Sonoma County Air Pollution Control District. Contingency plans to mitigate the impact of any unusually high H_2S encounter are referred to in Part F of this report.

Noise - Potential environmental impacts by increased noise levels exist from the various construction and drilling equipment and from testing of the wells. Mitigation of engine noise will be accomplished through the use of mufflers on the air compressor and drilling rig engines. Noise during air drilling will be abated by the cyclone muffler/separator described in part D 5 of this report. Altogether noise from drilling operations, even though of only 45 to 60 days duration, will be abated to a Ldn level of 65dB(A) at a distance of 0.80 km (0.5 miles).

Water - The proposed locations are in the drainage

basin of Big Sulphur Creek. Measures to prevent or mitigate potential impacts on stream and groundwater quality are detailed in part D 3 of this report.

Vegetation - The principal impacts will occur from the grading for well pad and access road preparation. Because these pads are designed to accommodate several wellheads each, surface disturbance is minimized when compared to a one well per pad field design. A study of Union Oil Company's Sonoma County leaseholds (Neilson, et al, 1975) covered all the lands involved in the proposed exploration. The study concluded that "no sources of vegetation impact are predicted ... for the leasehold" other than direct vegetation loss arising from removal of, and corresponding to, topographical modification. Even this impact can be mitigated by surface restoration and revegetation after cessation of drilling activities as required under GRO Order No. 4 under the direction of the Area Geothermal Supervisor. The extent of revegetation will depend on how much of the drill pad is required to maintain the wells. Increased fire hazards from drilling activities is a potential vegetative impact which will be mitigated as specified in part D 1 of this plan of operation.

The following reference was used in determining rare, threatened and endangered plant communities in the proposed exploration areas:

"The Geysers Mineral Reserve Lands - Proposed Geothermal Leasing Environmental Assessment Record Draft." Bureau of Land Management, Ukiah District, September 1978.

This assessment identified 3 rare or endangered plant species in the exploration area:

- 1) *Asclepias solanoana*, located in the general vicinity of the site for wells 71-31, A,B,C. The California Native Plant Society classifies this plant as rare, but not endangered.
- 2) *Ceanothus confusus*, located in the N.E. quarter of the S.E. quarter of Section 29, T11N, R8N. The California Native Plant Society classifies this species as rare, but not endangered.
- 3) *Lupinus sericatus*, located in the vicinity of the site for wells 42-33, A,B,C. This plant is

classified as endangered by the California Native Plant Society.

Prior to any ground work near these rare and endangered plant communities, Union Oil Company will contract a botanist or other vegetation expert to investigate the site and prepare an avoidance and/or mitigation plan.

Wildlife - Direct impacts to resident wildlife will be from alteration or removal of habitat for the construction of the proposed new access roads and pads. Displacement or elimination of the smaller and more sedentary forms of wildlife will be most affected. The affected areas will be a small fraction of the CA-959, CA-5639, and CA-5640 leases.

No drilling muds or other fluids associated with geothermal operations will be discharged to the surface other than to the sump, thus avoiding potential hazards to aquatic life of the Big Sulphur Creek drainage.

Observations at similar drillsites (Leitner, unpublished data) indicate that increased noise levels caused by well cleanouts, testing, and standby venting, as well as disturbance from human activity had little obvious effect on wildlife usage of adequate habitat (Neilson, et al, 1976).

The BLM Environmental Assessment Record of September 1978 states that endangered and fully protected wildlife species sighted in The Geysers area include the golden eagle, the peregrine falcon and the white-tailed kite. The observed use for all of these birds appears to be for foraging. No nesting is known to occur on or adjacent to the subject leases.

b. Land Uses

Visual Resources - While the scenic quality of the lease may be described as moderate, the overall visual sensitivity of the area is low, since the area of operations is out of view of any populated area or heavily traveled road. The visual impacts therefore would be minor. Proper and timely revegetation of the area would reduce visual impact of the otherwise exposed soils.

Cultural Resources - Prehistoric, historic and ethnographic inventories were completed by the Bureau of Land Management and recorded in the

Environmental Assessment Record prior to leasing. This inventory, in addition to sensible engineering practices, was taken into account in selecting road and drill site locations.

c. Socio-Economic Characteristics

The proposed exploratory project will not contribute significantly to the local population growth, employment or local tax revenues of the area. Only a minor increase in economic activity will be associated with the project.

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.

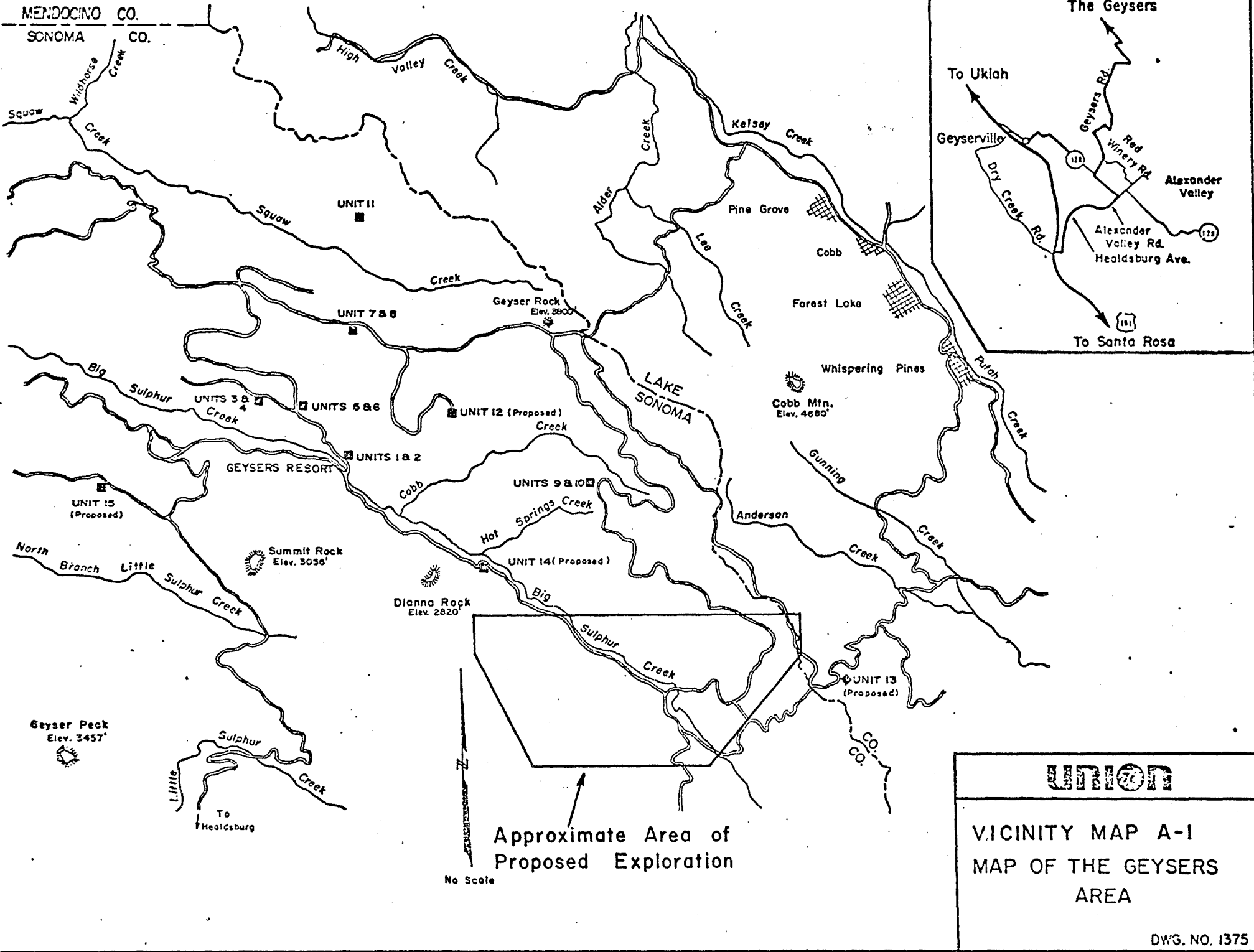
A successful exploratory project could lead to a development program for a 110 MW net electrical generating plant, which would contribute towards the nation's energy objectives. Such a project would also contribute significantly to local tax revenues.

EXHIBIT A

MAPS

MENDOCINO CO.

SONOMA CO.



UNION

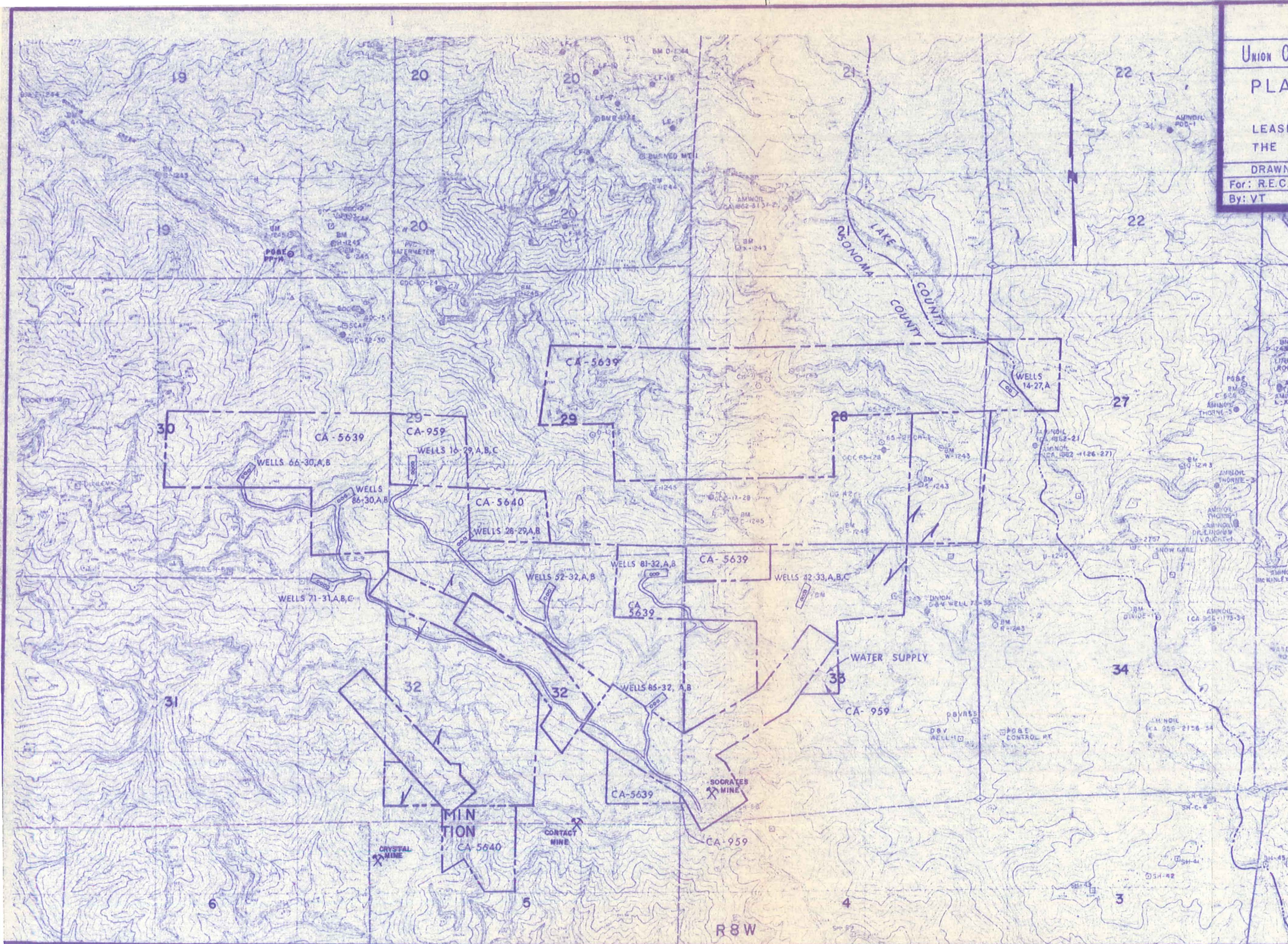
VICINITY MAP A-1
MAP OF THE GEYSERS
AREA

DWG. NO. 1375

**PLAN OF OPERATION -
EXPLORATION**

LEASE NOS. CA-959, 5639 & 5640
THE GEYSERS CALIFORNIA

DRAWN	DATE	SCALE	DRAWING NUM
For: R.E.C.	4-10-79	1"=1635'	3318
By: VT			Sheet of 1



LEGEND

- COUNTY LINE
- LEASE LINE
- EXISTING ROADS
- ===== PROPOSED ROADS
- ✦ ABANDONED WELL
- PLUGGED WELL
- EXISTING WELL
- PROPOSED WELL
- ⊞ WELL PAD

NOTE:
LEASE LINES ARE SHOWN USING
BEST AVAILABLE INFORMATION
TO DATE.

SCALE

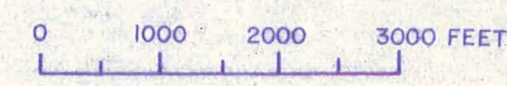


EXHIBIT B

EARTHWORK AND CONSTRUCTION

SPECIFICATIONS

SECTION 1 - INTRODUCTION

- 1.1 General: The following specifications will be followed for drill site and road construction at Union Oil Company's Binkley E-1.1 drill site. These specifications are of a general nature and may require deviations on a case-by-case basis.
- 1.2 Supervision: Work proposed will be under the supervision of a Civil Engineer and Engineering Geologist to inspect earthwork construction and perform tests necessary to assure that suitable materials are placed to design requirements and in conformance with these specifications.

SECTION 2 - PLANNING

- 2.1 Drill Site Locations: Drill sites shall be selected utilizing natural topographic features such as ridges, benches, shoulders and valleys which provide relatively flat areas of sufficient size to accommodate the drilling facility. The site shall be engineered to balance cuts and fills, thereby minimizing changes in natural contours, excavation operations and disturbance of vegetation. Areas of both inactive and active landslides are to be avoided, or if unavoidable, engineered in such a manner to insure the safe drilling and operation of geothermal wells.
- 2.2 Road Locations: Access roads shall follow existing trails where possible, in keeping within good design and construction practices. Road widths shall be limited to the width required for use and for safe equipment operation. In general, road widths shall be 14 feet and designated to accommodate single-lane traffic. Turnouts shall be provided at strategic locations. Roads shall follow natural contours of the land, with normal grades of 8-12%. Maximum grades of 18% are allowed in specific cases for distances not to exceed 50 feet.

SECTION 3 - EARTHWORK

- 3.1 Clearing shall consist of the removal of organic growth such as brush, grass, weeds, and other vegetation and debris and the disposal of such material designated for removal, including timber, brush, rubbish, and other matter occurring within the areas to be cleared. Construction areas for excavation and fill operations at the drill site, including berms

outside the drill site area for drainage control, shall be stripped of all vegetation and organic soils. Brush and tree growth shall be stockpiled and burned, or buried in spoil areas. The topsoil may be stockpiled for later spreading over cut and fill areas to enhance revegetation.

3.2 Earth Fills: All fill areas shall be benched and keyed into undisturbed ground. Embankments shall be placed in six to eight inch lifts, moistened as required, and compacted by tamping rollers or other approved compacting equipment. Mud sump fills shall be compacted to 95% and all other fills shall be compacted to 90% of ASTM D-1557-70, "Moisture Density Relations Test for Soils." Compacted fill slopes less than 30 feet in height shall not exceed 1 vertical on 1.75 horizontal and slopes over 30 feet in height should not exceed 1 vertical on 2 horizontal and shall be benched. Height between benches shall not exceed 25 feet.

3.3 Excavations: The Engineer will determine in the field the disposition of excavated material, including stockpiling of certain materials excavated for later use. Excavated materials free of organic materials and debris may be used in berms and for mud sump-disposal site liners, providing such materials conform to the requirements of California State Water Resources Control Board and are approved by the Engineer.

Cutslopes less than 15 feet in height shall not exceed 1 vertical on 1.5 horizontal. Slopes with heights greater than 15 feet should not exceed 1 vertical on 1.75 horizontal. Cutslopes higher than 30 feet shall be benched. Steeper slopes may be employed on a case-by-case basis by the Engineer where sound and durable rock is encountered. The top portion of the cut shall be rounded to eliminate a sharp break between the cut and the existing vegetation. The face of the cut shall be roughened or benched to enhance revegetation.

SECTION 4 - DRAINAGE AND EROSION CONTROL

4.1 Access Road and Drill Site Pad: Access road and drill site location surfaces shall be sloped to drain toward the cut side or upslope side of the roadway or drill pad. The slope shall be approximately two feet per hundred feet. A drainage system designed in accordance with the "Standards" of the Division of Highways, State of California, shall be provided to adequately carry water away that is collected on the surface of the roads or locations as well as water intercepted from upper slopes and natural drainage systems. The drainage system shall consist of ditches on the upslope side of roads and on the upslope perimeter of drill pads. These ditches shall be sloped to drain at a gradient between 1% and 2%, or greater with approval by the Engineer.

Sand/cement-filled bags shall be installed as energy dissipaters where required to reduce flow velocities and prevent erosion. The drainage ditches shall be conducted to culverts, sized, designed and installed in accordance with the above standards. Culverts shall be installed in accordance with the above standards. Culverts shall be installed with sand/cement-filled sand bag headwalls at the entrance, stilling basins at the exit, and shall be extended to existing natural drainage areas. An eighteen inch high berm shall be provided along the upper edge of all fill slopes to prevent runoff over the fill.

- 4.2 Treatment of Seepage Zones: Springs and seepage zones uncovered during excavation shall be drained by constructing "French" drains, syphon wells, or other means as determined by the Engineer, and conveyed to natural or site-constructed drainage ways for discharge.

SECTION 5 - REVEGETATION OF GRADED AREAS

- 5.1 General: Access road and drill site cut and fill slopes and other areas exposed by grading shall be revegetated in accordance with the recommendations in Appendix D.

SECTION 6 - PREPARATION OF DRILL SITE PAD AND ROAD SURFACES

- 6.1 Stabilization: Drill site pads and road surfaces shall be stabilized to improve trafficability and reduce soil loss during rainfall runoff. This shall be accomplished in cuts by scarifying the top 8 inches of surface. The top 8 inches of cuts and fills shall then be compacted by tamping rollers or other approved compacting equipment to 95% of ASTM D-1557-70, "Moisture Density Relations Test for Soils." Moisture contents in excess of allowable working limits may be hydrated, using approximately 10% by volume or 0.2 cubic feet per square foot surface area of either pozmix cement or quicklime. The surface shall be finished by grading and intensive rolling with a smooth steel or rubber-tired roller.
- 6.2 Surfacing: Access road surfaces shall be finished by placement of a suitable thickness of gravel or native rock or armor-coated for all-weather use, as determined by the engineer.

**SECTION 7 - PREPARATION OF
MUD SUMP-DISPOSAL AREAS**

7.1 General: The drilling mud sump shall be constructed to the requirements of the California State Water Resources Control Board for Class II-1 disposal site in order that spent drilling muds can be disposed of at the site. The disposal site will have the natural characteristics or will be engineered in such a manner to preclude the seepage or migration of any leached and deleterious materials contained within the sump to usable surface and groundwater.

7.2 Impervious Liners: A soil, soil cement or lime cement, or vinyl (PVC) liner shall be constructed when native or imported soils do not meet requirements for permeabilities of less than 1×10^{-6} centimeters per second. Liner selection will be made by the Engineer depending on weather conditions and the availability of materials. The slopes of containment areas should not exceed 1 to 2 and the bottom width should not be less than five feet regardless of which type of lining is employed. Specifications for the placement of each liner type is as follows:

1. Impervious Soil Lining

Weather conditions and availability of suitable materials permitting, an impervious clay lining shall be utilized. The soil lining shall conform to the inside pit configuration and placed in such a manner to resist accidental damage from pumping and other operations. The soil in the sump shall be thoroughly compacted to 95% of ASTM D-1557-70 prior to placement of the liner. A two-foot-thick clay lining of materials approved by the Engineer shall then be applied. The lining will be placed in six-inch layers using soil having a suitable clay content. The lining material shall be moistened to optimum moisture content and compacted to at least 95% of ASTM D-1557-70. Each layer will be compacted by means of a sheepsfoot or other suitable compacting roller. The surface of the clay lining will be finished by trackwalking with a track-laying tractor. The permeability of the lining as placed shall not exceed 1×10^{-6} centimeters per second.

2. Soil Cement or Lime Cement Lining

When soil moisture content is in excess of allowable working limits, a soil cement or lime cement lining may be employed. Quick lime or prozmix cement in the amount of approximately 10% by volume shall be added and thoroughly mixed into selected soil having a suitable clay content. The mixed material shall then be spread throughout

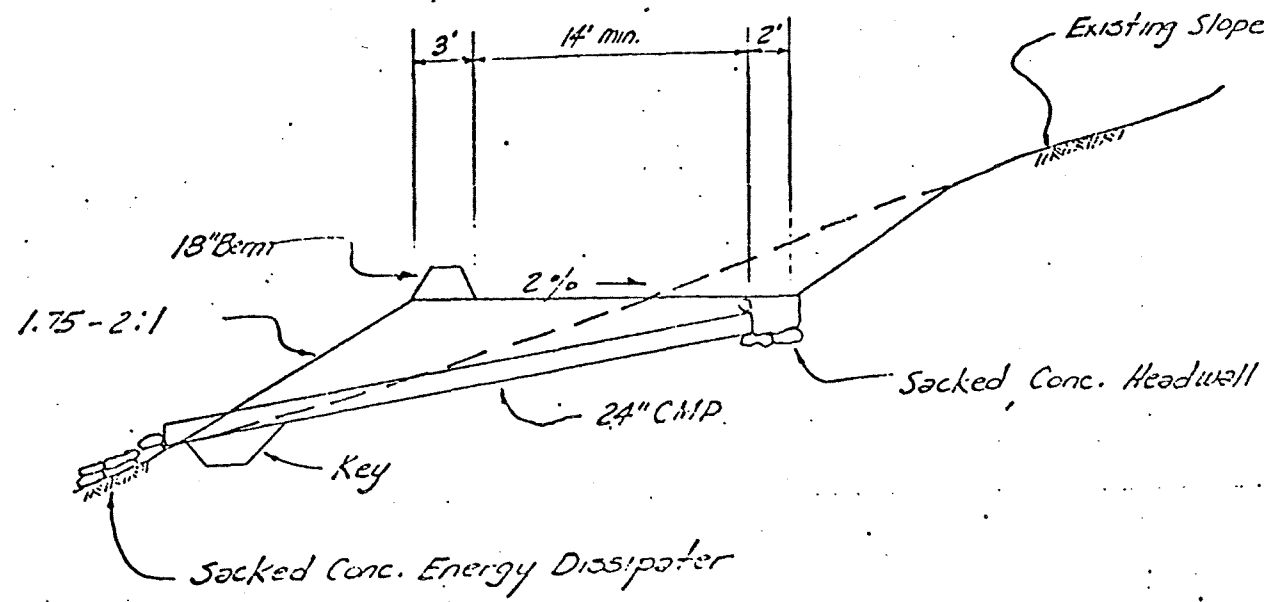
the sump area in six-inch layers and compacted to at least 95% of ASTM D-1557-70. This procedure should be repeated four times until a two-foot-thick minimum impervious lining is created. Each layer shall be compacted by means of a sheepsfoot or other suitable compacting roller. The surface of the lining shall be finished by track-walking with a track-laying tractor. The permeability of the lining as placed shall not exceed 1×10^{-6} centimeters per second.

3. Vinyl (PVC) Membrane Lining

The sump area shall be carefully compacted to present a smooth surface. Rocks, rock fragments, and other material which might puncture the membrane shall be removed. A light sand or sand-cement fill, one to three inches in thickness, may be added to assist in providing a smooth surface. A vinyl membrane not less than 20 mils in thickness may be applied to assist in producing a smooth surface. A vinyl membrane not less than 20 mils in thickness shall be applied. The vinyl shall be prefabricated to meet the requirements of the individual ponds and shall be packaged so that it may be unfolded into place without the necessity of pulling or dragging the membrane. The membrane shall be spread with sufficient slack to accommodate temperature changes. A ditch approximately 12 inches deep shall be excavated at the perimeter of the sump.

After placement of the vinyl lining, an earth fill, approximately 12 inches in thickness and composed of fine sand, silt and clay, free from coarse sand and rock fragments, shall be placed to hold the lining in place and to protect it. To prevent damage to the lining during drilling operations, it is recommended that supports be provided for suction and discharge lines. After filling the sump, the edges of the lining shall be buried in the 12-inch-deep perimeter ditch and the ditch backfilled.

- 7.3 Drill Site Disposal Area Abandonment: Upon completion of drilling operations at drill site locations, the mud sump-waste disposal area shall be dewatered by solar evaporation or by pumping with the final drying of the waste material by solar evaporation. When the moisture content of the waste material is reduced to 30% or less, the sump contents shall be mixed with native soils and the sump back-filled. An eighteen inch high compacted berm shall be installed between the sump area and the drill site location pad to prevent water from running off the pad onto the sump. The surface of the disposal area shall be sloped to drain, graded for an attractive appearance, and revegetated.



TYPICAL CROSS SECTION
INTERCEPTOR CULVERT

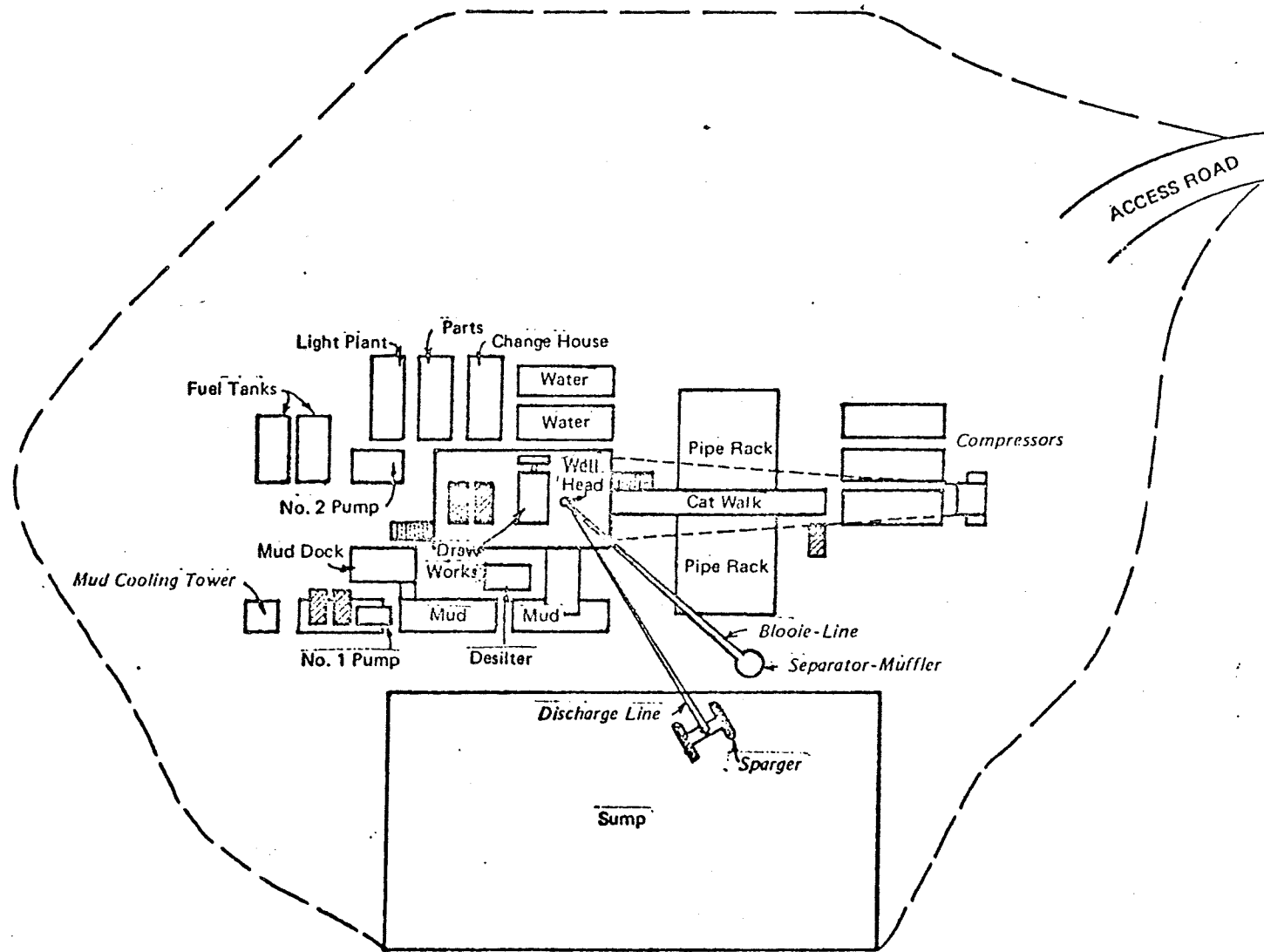
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Figure 3



Notes:

Used for Steam Only

- Blooiie-Line

- Separator-Muffler

- Compressors

Used for Water Only

- Discharge Line-Sparger

- Mud Cooling Tower

General Composite Layout of Typical Geothermal Well Drilling Facilities for Steam and Hot Water

EXHIBIT C

SPECIFIC LOCATION

GEOLOGICAL DESCRIPTIONS

CA 5639

CA 959

CA 5640

The Geysers, California

PRELIMINARY GEOTECHNICAL EVALUATION OF POTENTIAL GEOTHERMAL WELL SITES ON FEDERAL MINERAL LEASES CA 5639, CA 959, AND CA 5640, THE GEYSERS, CALIFORNIA

This exhibit presents a preliminary site-specific description of the potential well sites on Federal leases CA 5639, CA 959, and CA 5640 at The Geysers Geothermal field Sonoma and Lake Counties, California.

The purpose of the exhibit is to provide geotechnical data required by the U. S. Geological Survey for the "Plan of Exploration, Operation and Drilling" for the three parcels. The three Federal parcels are located in Union Geothermal's proposed Units 18 and an unnamed development areas.

Geotechnical opinions expressed regarding the individual sites are based primarily on a cursory examination by Union Geothermal, regional geologic mapping by the U. S. Geological Survey and aerial photo interpretation. Considerable additional work will be performed at each site prior to submittal to the State and Federal regulatory agencies for approval.

Union Geothermal's well site designation was not used to describe the well sites on the Federal parcels. Instead they are referred to those sites containing potential wells according to the U. S. Geological Survey well numbering system. The well sites will be assigned Union's classification at a later date.

SITE FOR PROPOSED WELLS 85-32, A, B, C.

The well site containing proposed wells 85-32, A, B, C, is located in the extreme southeast and triangular corner of Federal Mineral Lease CA 5639. The site is located in the NE quarter of the SE quarter, Section 32, T 11 N, R 8 W, MDB&M.

The general site location is on a northeast sloping spur from the main ridge crest which separates Big Sulphur Creek drainage from that of Little Sulphur Creek. The area on the spur where the site is planned consists of a low saddle and a knoll. Length of the area which appears to be suitable for development of a well site is about 600 feet. Width of the spur crest varies from about 100 to 150 feet. The site therefore appears to be feasible for a multiple well site containing a maximum of four wells. Elevations of the site vary from 3209 feet in the saddle to 3221 feet on the knoll.

Access to the site area can be provided by improving an existing jeep trail which leads from the crest of the main ridge.

Geologic units in the immediate well site area mainly consist of a sequence of northwest trending greenstone and graywacke units. The sequence is bounded by serpentinite which underlies the crest of the main ridge. From the serpentine contact which is 200 feet from Elevation 3354 on the main ridge crest, the sequence of rock units from southwest to northeast consists of greenstone (250 feet), graywacke (150 feet), greenstone (200 feet), graywacke (120 feet), greenstone (75 feet) and an undetermined thickness of graywacke at

the northeast end of the spur and end site. In addition to the graywacke and greenstone rock units, a few tectonically emplaced and isolated lenses of glaucophane schist are present beneath the saddle area of the spur. Both the greenstone and graywacke units are mostly moderately to, in places, intensely-fractured and sheared.

Shearing and faulting in the site is dominantly northwesterly and steeply dipping. The more highly sheared rock underlies the saddle area and where the schist is present.

No landslides affect the crest of the spur where the well site is planned. An inactive and older landslide is present downslope of the knoll (elevation 3221), facing southeast toward the Socrates Mine but the main scarp of the landslide is more than 200 feet from the crest. Another, but much larger and ancient landslide is located downslope and northerly of the well site area, which heads about 300 feet of the crest. Neither landslides affect the proposed drill site area.

Vegetation on the site consists of thick brush with a few scattered stunted trees.

The site appears to be a feasible site for three to four geothermal wells. The major problem with the site appears to be the location of a mud sump sufficient for the drilling of three to four wells. A possible location for a sump is in the area immediately south of the saddle.

SITE FOR PROPOSED WELLS 81-32 A, B.

A proposed well site for wells 81-32 A, B is located in the central portion of Lease CA 5639 and in the NE quarter of the NW quarter of Section 32, T 11 N, R 8 W. It is situated on a terrace-like area about two-thirds the distance downslope of the main ridge towards Big Sulphur Creek. The more gently sloping portion of the terrace is approximately 500 feet in length and 250 feet in width.

No roads or trails exist to the site area. Access is possible by constructing a 1500 foot-long road from the southeast and from the Socrates Mine road.

A cursory review of the site area indicates the terrace area to be underlain entirely by graywacke rock. In-place graywacke rock was found to occur along the stream bordering the area to the south and between the stream and the edge of the terrace. A soil zone blankets the upper portion of the terrace which obscures rock exposures. Characteristics of the soil zone, however, indicate that the entire terrace area is underlain by in-place rock. Where rock exposures do occur, the rock is moderately to intensely fractured and moderately sheared.

No landslides were delineated in the immediate site area. A large landslide does occur immediately west of the site which extends

upslope between the site and the knoll at Elevation 2834 feet. The landslide will not affect the well site area but the access road may cross the toe of the landslide.

Vegetation consists of heavy brush and a few small trees.

The site appears to be suitable as a multiple well site with several design options. A detailed geotechnical investigation is recommended to confirm the preliminary conclusions that in-place graywacke rock underlies the terrace.

SITE FOR PROPOSED WELLS 52-32, A, B.

A proposed well site containing wells 52-32, A, B in the central portion of Federal lease CA 5639 is located in the NW quarter of the NE quarter of Section 32 T 11 N, R 8 W. It is located on a north-east trending spur of the main ridge separating Big Sulphur and Little Sulphur Creeks. The site is located about halfway between the crest of the main ridge and Big Sulphur Creek.

Access to the site is by way of an existing jeep trail from the Eureka Mine. The grade of trail in places exceeds that which would be suitable for two wheel drive vehicles, but the general trail alignment appears to be suitable for an improved road to the site.

Geologic units underlying the site are mainly northwest trending and steeply dipping. From the knoll at Elevation 2852 feet the underlying rock is graywacke to a saddle area 200 feet to the northeast. From the saddle to a knoll Elevation 2833 feet, the underlying rock is a highly sheared zone consisting mainly of sheared shale and graywacke with tectonically emplaced and isolated blocks of chert. Northeast of Elevation 2833 to Elevation 2867, the area is underlain by massive graywacke with chert exposed at the extreme north end of the site.

Two northwest trending and steeply northeast dipping parallel faults cross the site area to form the more highly sheared zone delineated by two saddle areas.

No landslides were found to occur in the immediate site area.

The site appears to be feasible for a multiple well pad. Several site design options exist for the area. The most promising design appears to be one where the well site is oriented northwesterly in the saddle area.

SITE FOR PROPOSED WELLS 71-31 A, B, C.

A drill site to drill wells 71-31 A, B, C is located along the north edge of the NE quarter of the NE quarter of Section 31 T 11 N R 8 W. The site is situated on the crest of the main ridge between Big Sulphur and Little Sulphur Creeks. It is immediately outside the Fed-

eral Mineral Rights parcel CA 5639 in Section 30. Proposed wells for the site, however, can be directionally drilled to reach targeted areas beneath the Federal lease.

Access to the site is by way of an existing road along the crest of the main ridge.

The site is underlain by serpentinite and graywacke rock units. Most of the site is underlain by serpentinite, which is continuous for a considerable distance south of the site. The serpentinite occurs beneath the saddle area by Elevation 3418 feet southward to the knoll at Elevation 3439 feet. The graywacke underlies the ridge crest west of the saddle by Elevation 3418 feet and the amphitheater-shaped area immediately to the south in the Little Sulphur Creek drainage. A north-northwest trending fault appears to separate the serpentinite and graywacke units cutting diagonally across the ridge crest.

No landslides occur in the vicinity of the ridge crest where the site is located. The flanks of the ridge to the northeast and southwest have topography suggestive of landslide terrain, but in-place rock was found in these areas. A small landslide does occur about 150 feet northwest and removed from the site which heads along the serpentinite-graywacke contact.

Vegetation consists entirely of medium height brush.

The site appears to be feasible for a multiple well site.

SITE FOR WELLS 42-33, A, B, C.

The site for wells 42-33 A, B, and C is located on a gently sloping area 1,000 feet northwest of the proposed Unit 18 power plant location. It is proposed as a three-well site.

Access to the site area is by way of the Socrates Mine Road, which is within a few tens of feet of the proposed site. Elevation of the site is about 2,500 feet.

Few outcrops occur in the area underlain by the site. Some exposures, however, are found a short distance away at the base of the Socrates Mine Road cut. In addition, other exposures were found to the northwest. The data indicates the site area is probably underlain by some serpentinite and, more likely, metamorphosed graywacke and shale. The unit lies within a few tens of feet of intensely hydrothermally altered rock to the northeast but the rock beneath the site is only slightly altered.

Possible landslide debris may underlie a portion of the drill site area. Glauconite schist debris was mapped immediately upslope of the drill site which was probably derived from the unit underlying Unit 18.

It is not known at this time if the site can be utilized since there is some question as to its stability. Because of this, a detailed geotechnical investigation will be required. If the site is found to be underlain by landslide debris an alternative site is available immediately to the north. This is the area underlain by the northwest trending ridge and where Elevation 2552 feet is shown on the 1 inch to 200 feet VTN map.

SITE FOR PROPOSED WELLS 86-30 A, B.

The well site for proposed wells 86-30 A, B is located in the NW quarter of the SE quarter of Section 30 T 11 N R 8 W. The well site is in Federal Lease CA 5639. The location of the site is on a gently sloping crest of a spur from the main ridge which lies between Big Sulphur and Little Sulphur Creeks. Elevation of the site varies from 3075 to 3150 feet.

Access to the site is by way of a jeep trail. The general alignment of the trail can be used for the access road to the site.

All of the site area is underlain by graywacke which contains minor shale. Exposures are generally poor on the spur crest but in the deeper road cuts the rock is moderately to highly sheared and fractured. The graywacke appears to trend northwesterly beneath the site.

No landslides affect the crest of the spur where the site will be located.

The site appears to be marginal for a multiple well site. Depending on the site design extensive excavation and filling may be required to obtain the required level area for a two-well site.

SITE FOR PROPOSED WELLS 16-29, A, B, C.

The well site for proposed wells 16-29, A, B, C is located in the SW quarter of the NW quarter of the SW quarter of Section 29, T 11 N R 8 W. The site is on a spur and flat area about halfway between the main ridge and Big Sulphur Creek.

Access to the site is now by way of jeep trail along the crest of the spur leading from the main ridge. The grade of the existing trail is in excess of that which is required for drill site access, and for that reason cannot be used. A jeep trail which may be suitable with widening leads to the site area from the west. If not, access can be obtained with construction of a road to the southeast which would also provide access to two other sites on the lease.

Geologic conditions beneath the site are complex and were not fully

resolved during the cursory examination of the site. Most of the bedrock underlying the site is greenstone and the site is at the edge of a contact between the greenstone and a predominantly graywacke unit upslope. In-place greenstone is exposed in the saddle area at Elevation 2796 feet and beneath the entire hill which has a peak elevation of 2882 feet. Greenstone bedrock is also exposed at the end of the trail which leads toward the intermittent stream south of the site.

A major ancient inactive fault appears to separate the greenstone underlying the site from the graywacke unit upslope. Exposures in the fault area indicate the rock to be intensely sheared and fractured.

An apparent landslide with a width of 400 feet and a length in excess of 1,000 feet appears to underlie the enclosed depression at Elevation 2777 feet and the low northeast oriented ridge under Elevation 2804 feet. In the area south of and west of the depression no in-place rock was found with only randomly oriented rock fragments indicative of landslide debris. The presumed scarp area for the landslide is poorly defined, indicating a very old age for the landslide.

Although the results of the cursory examination strongly suggest the presence of an ancient landslide, a feasible multiple well site could be constructed using the saddle area underlying Elevation 2796 and the adjacent knoll. A detailed geotechnical investigation would be required to determine the depth and areal extent of the landslide.

SITE FOR WELLS 65-29, A, B, C.

The site for wells 65-29, A, B, C is for the Federal lease CA 5639 and the portion of the lease which lies north of Big Sulphur Creek. The site is on the southern edge of the lease and mostly on private lands south of the lease. The drill site and proposed wells are located in the Big Sulphur Creek drainage in the southwest quarter of the northeast quarter of Section 29, T11N, R8W, M.D. B&M. The approximate size of the site is 350 feet in length and 300 feet in width including the mudsump.

The site has been explored in detail and some required data has been submitted to the California Division of Oil and Gas for approval as the GDC 14 19.3 well site containing wells Biegel No. 1, GDC No. 12, and Biegel No. 2 wells. The U. S. Geological Survey wells 16-29 A, B, C are these same wells.

Both the drill site pad and mud sump are located on the end of a topographic nose which juts out from the southerly sloping flank of a main ridge through The Geysers. The nose trends in a southwesterly direction. Elevations on the topographic nose where the site will be constructed varies between 2220 and 2100 feet.

The site area is underlain by two geologic units; intrusive ser-

pentine and greenstone. The serpentinite is on the upslope side of the well site while the greenstone is on the downslope side. A fault lies between the two units.

The fault separating the two rock units includes a zone several tens of feet in width of highly sheared rock. Almost all of the zone is in the relatively weaker serpentinite. The fault strikes northwesterly and dips steeply to the northeast.

No landslides underlie the site but both older and recent landslides occur adjacent to the site. Two older landslides were delineated in the more highly sheared portion of the serpentinite and three recent landslides occur in the cutslope for the existing road.

The detailed geotechnical work performed at the site indicates that it is feasible as a three-well site.

SITE FOR WELLS 66-30, A, B.

The proposed drill site for geothermal wells 66-30, A, B is planned as a three-well site. It is located in the NW quarter of the SE quarter of Section 30 T 11N, R 8 W MDB&M on a northeast trending ridge at Elevation 3025 feet to 3047 feet. The site is in the Federal Mineral Lease CA 5639. Topography of site is gentle, with flanks of the site falling off moderately to the west and east. Vegetative cover is thin because of a 50 foot-wide swath cut for the fire road over the top of the site and because of a fire that burned most of the area.

Access to the site is by the Cadd Fire Trail located on the northwest trending ridge southwest of the site and by subsidiary fire trails. These roads will have to be modified and improved to accommodate the additional usage.

Bedrock conditions are obscured by lack of exposure in the site area. In-place graywacke is exposed in an unmapped road 50 feet west of site and in the fire trail just north of the site. Along the road over the site, however, there is only graywacke debris, none of which is definitely in place. The graywacke debris and the exposed bedrock is slightly metamorphosed and highly fractured and sheared.

Numerous landslides occur off the flanks of the ridge, some of which may affect the site area. The toe of another apparent landslide may underlie the southern edge of the site. All of the debris in these slides is pebble to cobble-sized angular fragments of graywacke.

The site appears suitable for a three-well pad. A detailed geotechnical investigation is recommended to accurately delineate the landslides and determine the best site design and layout.

The proposed geothermal drill site for wells 14-27, A is planned as a two-well site. It is located on the Sonoma-Lake County line in the SW quarter of the NW quarter of Section 27 on the ridge dividing the Big Sulphur Creek drainage to west from the Andersen Creek drainage to the east. The pad is in the Federal Mineral Lease CA 5639. Elevation of the site varies from 3,210 feet to 3,250 feet. Topography of the area underlain by the site is gently rolling but the ridge falls off steeply to both the west and east. Although most of the site is clear of dense vegetative cover, some brush is present on the flanks.

Access to the site is by an existing gravel road that will need little improvement. The site layout will be sub-parallel to the road.

Most of the site is underlain by Franciscan graywacke. The graywacke is slightly to moderately metamorphosed and forms resistant outcrops in most of the site area. It is highly fractured with fractures spaced from 1/2 " to 4", mostly in random directions but with some through-going shears. The graywacke is gray to greenish on fresh surfaces and generally weathers to a buff color west of the road and reddish color east of the road. Included in the graywacke mass are bodies and lenses of other rock types.

Most of the intruded rock is serpentinite. Two bodies are mapped, one about 50 feet round at the north end of the site and one cigar-shaped body 100 feet by 200 feet at the south end of the site. These bodies are composed of extremely sheared green to black-colored serpentinite with included blocks of partially serpentinitized peridotite up to 3 feet in size.

Some shale was encountered while mapping the area. Exposures are generally present only in drainages, though other portions of the site area are thought to be underlain by it. The shales are black-colored, highly sheared and include lenses (interbeds?) of graywacke. In some areas, the interlayering is very rhythmic but exposures are too small to evaluate in detail.

One chert body was encountered and is located in the west central portion of the site. It is green-colored, highly fractured and lacks the banding typical of most Franciscan cherts.

Numerous springs were encountered, but because the area was mapped immediately following a heavy rain and because there was no associated lush plant growth, they are considered to be of short duration.

No hydrothermally-altered rock was encountered in the area.

No problems with construction are anticipated. Topography and bedrock conditions are well-suited for construction of a geothermal drill site.

SITE FOR WELLS 28-29, A, B

The proposed drill site for the geothermal wells 28-29, A, B is planned as a 2-well site. It is located in the SE and SW quarters of the SW quarter, Section 29, T11N, R8W, MDB&M on a northeast-trending spur. Elevation of the proposed site varies from 2,719' to 2,750'. Topography along the spur is moderate, but falls off very steeply to both the northwest and southeast. The site is covered by a dense growth of brush.

At present, there is no easy access to the site. A fire road comes within 150' west of the site, but the road is washed out about 2,000' further west. The road is part of the fire trail system connected to the Cadd fire trail. These roads will have to be modified and improved prior to development.

Most of the site area is underlain by Franciscan greywacke. The greywacke is slightly metamorphosed and highly fractured and sheared. Spacing of the fractures varies from 1/4 to 2 inches. One tectonic block of bonded chert was mapped just west of the knob of the spur.

At the northeast end of the site, 75' southwest of a saddle, a steeply dipping east-west trending fault separates the greywacke to the south from a greenstone body to the north. The greenstone is highly sheared and fractured and slickensides can be observed on many fragments. Another fault is interpreted to exist through the saddle of the southwest end of the site. It separates the slightly metamorphosed greywacke to the north from more highly metamorphosed greywacke to the south.

Only one landslide appears to affect the site area. It is located at the northern corner where greywacke debris has slid over the greenstone.

Suitability of the site for construction of a multiple well site with more than 2 wells is questionable. Because of the steep slopes to the northwest and southeast, the site will have to be deeply excavated, and there may not be a suitable location for the sump. A possible site design includes excavation of the knob and utilization of the excess material to construct a sump across the saddle to the southwest.