GL03140

NOV 16 1979

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

NOV 9 1979

Memorandum

To: Interested Parties

From: Acting Area Geothermal Supervisor

Subject: Plan of Development, Aminoil USA, Inc., Federal Lease CA-1862, Geysers-Calistoga KGRA, Lake and Sonoma Counties, CA.
Ref: 2403-01 CA-1862 (POO for EA #136-80)

Aminoil USA, Inc. has submitted a Plan of Operation for Development in accordance with 30 CFR 270.34 to construct five multiple-well pads, drill nine or more exploratory wells and construct a steam transmission pipeline for the steam supply to the proposed Sacramento Municipal Utilities District (SMUD) electric generation unit No. 1 on Federal Lease CA-1862 in the Geysers-Calistoga KGRA, Lake and Sonoma Counties, California. A copy of the Plan is enclosed for your review and files.

An Environmental Assessment (EA #136-80) will be prepared by the Office of the Area Geothermal Supervisor for the proposed action.

You are invited to participate in a field inspection being led by Ted Hudson, Santa Rosa District Geothermal Supervisor, USGS, on December 5, 1979. Participants are asked to meet at the Chevron Service Station in Middletown, California, at 9 a.m..

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 December 19, 1979, by:

Area Geothermal Supervisor
US Geological Survey - Conservation Division
345 Middlefield Road - MS 92
Menlo Park, CA 94025

Tel: (415) 323-8111, Ext. 2845 (FTS: 467-2845)

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 draft EA's to the surface agency, the lessee, Geothermal Environmental Advisory Panel 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 and Bureau of Land Management manager's office having responsibilities for the areas under consideration.

(Original Sgd.) Bruce H. Hellier

for Reid T. Stone

Enclosures

bcc: Reading File 101-02
Subject File 2403-01 (POO for EA #136-80)
DGS, SLC, UT
DGS, RNO, NV
ENV
ENG

BDeTar/km/11/08/79

INTERESTED PARTIES EA #136-80

Aminoil USA, Incorporated
Plan of Development

CA-1662
Geysers-Calistoga KGRA

* * * * *

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California State Director
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2800 Cottage Way
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2800 Cottage Way, Room E-2720
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Department of Energy, Division of Geothermal Resource Management
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Washington, D.C. 20545

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INTERESTED PARTIES for EA #136-80

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INTERESTED PARTIES for EA #136-80

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Gulf Mineral Resources Company
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Reno, Nevada 89511
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Plan of Development Operation

Lease Unit No. 7 West CA 1862
Sections 21, 28 and 29, T11N, R8W
Geysers Area KGRA
Lake and Sonoma Counties, California

September 15, 1979

Aminoil USA, Inc.
P. O. BOX 11279
Santa Rosa, CA 95406
(707) 527-5332

Plan proposes construction of five well pad sites for the drilling of nine or more geothermal resource wells and constructing a pipeline for the steam supply to the Sacramento Municipal Utility District Electric Generation Unit 1. Drilling of the wells is scheduled to begin in 1980 with construction of the steam supply pipeline system scheduled for 1982-83.

Aminoil USA, Inc.
Plan of Development Operation

CONTENTS

EXHIBITS

Plan of Development Operation
Lease Unit No. 7 West CA 1862
Sacramento Municipal Utility
District (SMUD) Electric
Generation Unit 1

A. INTRODUCTION

Pursuant to 30 CFR 270.34, Aminoil USA, Inc., formerly Burmah Oil and Gas Company, hereby submits its Plan of Development Operation Lease Unit No. 7 West CA 1862. The Plan proposes construction of five well pad sites for the drilling of nine or more geothermal resource wells, construction and installation of a steam supply pipeline system to provide the steam supply for the Sacramento Municipal Utility District (SMUD) Electric Generation Unit 1. A concrete sedimentation basin will be constructed near the power plant to receive excess condensate from the plant cooling towers. A small section of new road will have to be constructed for access to the most westerly well site.

B. DETAILS OF THE PLAN OF DEVELOPMENT OPERATION

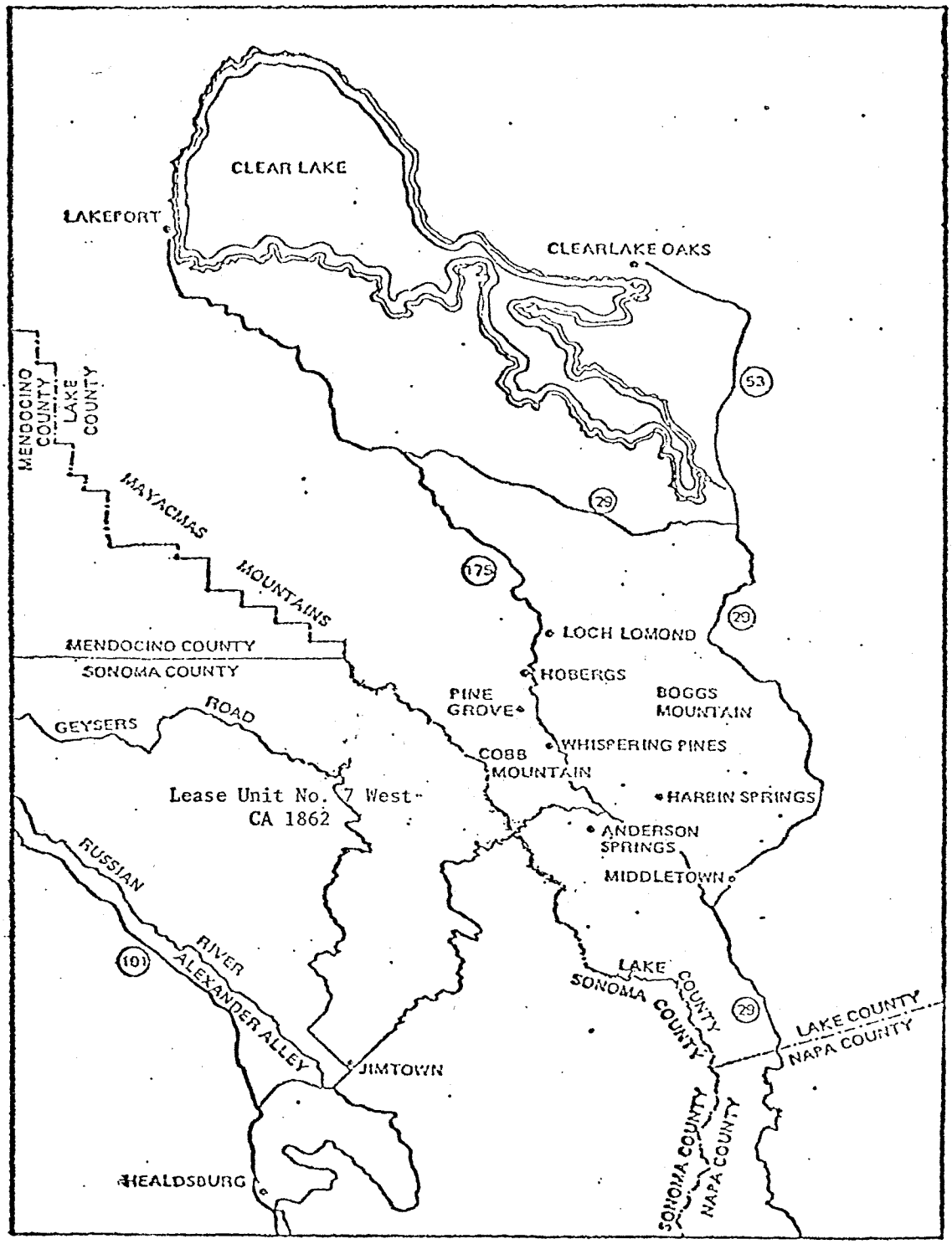
1. Site Location

The project site is located in the Geysers Area KGRA, Lake and Sonoma Counties, California (see Exhibit "A" Regional Map (page 2) and Exhibit "B" Area Map (page 3)). The project area encompasses about 160 hectares (396 acres), including the S 1/2 of W 1/2 of Section 21, the N 1/2 of N 1/2 of W 1/2 Section 28, the N 1/2 of N 1/2 of E 1/2 Section 28, and the N 1/2 of N 1/2 of E 1/2 Section 29, T11N, R8W, MDB & M. Access to the project site is from Highway 175 via Socrates Mine Road and the California Division of Forestry Service Road which has been previously improved for exploratory drilling operations.

2. Reservoir Characteristics

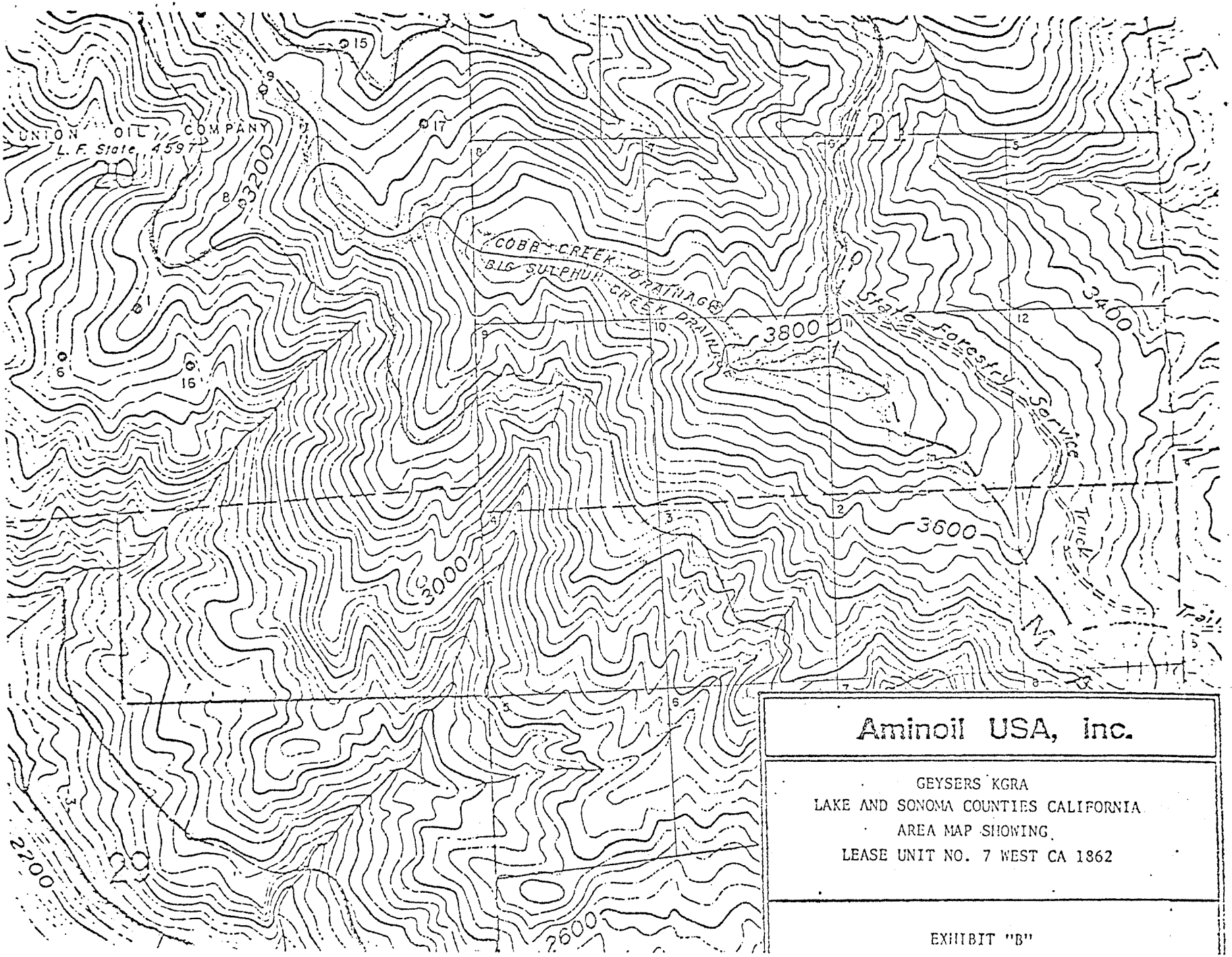
The geothermal resource from one well, CA 1862-3 (37-21), on Federal Lease Unit No. 7 West as with the balance of the wells in the Geysers Geothermal Development Area, is dry steam generally at saturation. Results of tests identifying the characteristic of the steam from the CA 1862-3 (37-21) well are on file with the USGS office of the Geothermal Supervisor, Menlo Park, California. Characteristics of the steam produced from the wells to be drilled is not expected to differ materially from that produced from the now completed well.

Well CA 1862-3 (37-21) encountered reservoir rock at measured depths below 1149 meters (3769'). Though the well penetrated approximately 1210 meters (3970') of reservoir rock, it is not believed that basement was reached. Although the total area of the leases committed to development for the SMUD Unit is considered to be productive, the thickness of the reservoir has not yet been defined. Porosity and permeability of the metagraywacke reservoir rock is low. Permeability in the reservoir is thought to be the result of fractures. Static pressure at each well head is expected to be $\pm$ 32 Kg/cm^2 (450 psig) as encountered in wells previously drilled. As noted, reservoir fluid is dry steam, generally at saturation, with little or no free water. Production from the wells completed in the SMUD Unit 1 project area and on offset properties ranges from 38,600 Kg/hr (85,000 lbs/hr) to over 91,000 Kg/hr (200,000 lbs/hr). The wells yet to be



REGIONAL MAP

EXHIBIT "A"



Aminoil USA, Inc.

GEYSERS KGRA
LAKE AND SONOMA COUNTIES CALIFORNIA
AREA MAP SHOWING
LEASE UNIT NO. 7 WEST CA 1862

EXHIBIT "B"

drilled are expected to be within this range.

Wells to the northwest of the development area have been supplying steam to PGandE's Units 9 and 10 since 1975. Production rates at these wells have experienced some decline over time. It is expected that the well drilled to date, those to be drilled under this Plan of Development, and additional replacement wells will provide adequate steam supply for the commercial operation of the 55 MW SMUD Unit 1 for at least a 30 year period.

3. Well Spacing

Spacing of wells to be developed from Federal Lease Unit No. 7 West CA 1862 for the SMUD project will be determined following evaluation of reservoir characteristics to determine optimum production from a minimum number of wells. Surface locations will be selected to correlate with bottom hole objectives and precisely located following an evaluation of topographic features, drainage areas and surface geologic conditions (refer to Exhibit "C", Geologic Map - Appendix 1 for details). Detailed information on well spacing and bottom hole locations will be filed with Applications to Drill (Form 9-331C) under separate cover.

Five multiple well pad sites will be developed in an effort to minimize surface disturbance and the resultant environmental impacts. Where appropriate, site specific geotechnical studies have been performed and a report of the findings will be forwarded upon completion of each study. A typical drilling site is represented by Exhibit "D" page 5. The five multiple well pad sites will also provide locations for the drilling of replacement wells which might become necessary to maintain the steam flow rate required to operate the plant for the life of the project.

4. Representative Drilling Program

A detailed drilling program for well CA 1862-3 (37-21) has been submitted previously with the Application to Drill (Form 9-331C). The drilling program for any future well is not expected to differ materially from that approved for the above mentioned well. Profile of a typical geothermal well is depicted by Exhibit "E" page 6.

5. Steam Reservoir Adequacy and Commercial Utilization

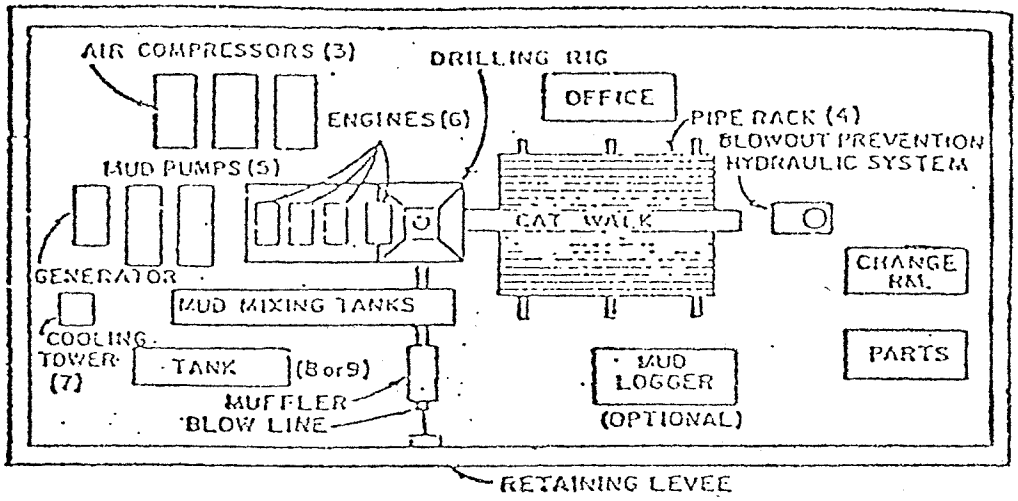
Due to the high productivity of several offsetting wells (over 91,000 Kg/hr (200,000 lbs/hr)) and the presence of productive wells to the west, south and east of Federal Lease Unit No. 7 West, Aminoil USA, Inc. has determined that an adequate steam reservoir exists to supply steam for the commercial operation of SMUD Geysers Power Plant Unit 1. Aminoil has committed the approximately 160 hectares (396 acres) of Lease Unit No. 7 West to production of steam for the operation of the 55 MW plant.

SMUD Unit 1 is now expected to start commercial operation by January 1984.

6. Steam Accountability

Only steam from Lease Unit No. 7 West will be used for the operation of SMUD Unit 1. Production from individual wells will be accounted for by individual well orifice meters in accordance with GRO Order No. 7.

TOP VIEW OF A TYPICAL DRILLING SITE



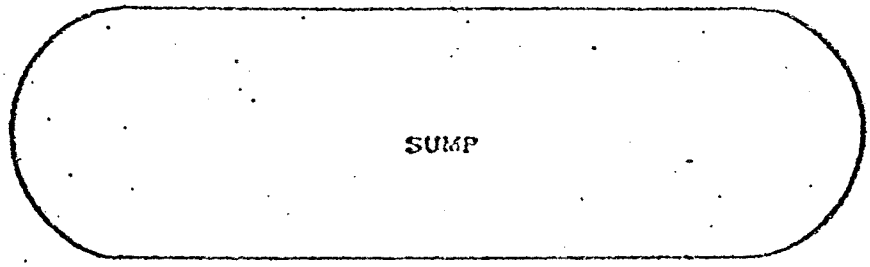
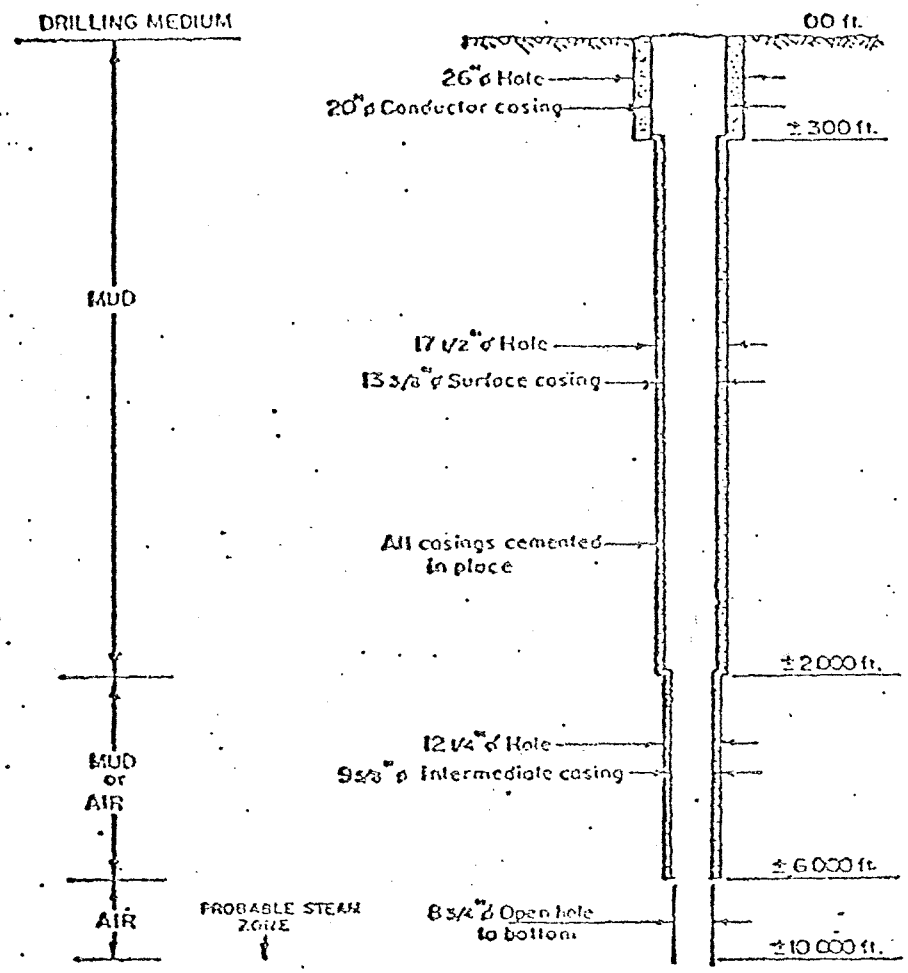


EXHIBIT "D"



PROFILE OF TYPICAL GEOTHERMAL WELL

EXHIBIT "E"

7. Proposed Development

The Plan of Development Operation proposes drilling nine or more geothermal resource wells from five multiple well pads, construction and installation of about 5300 meters (17,400') of steam supply pipeline and an unspecified amount of condensate pipeline. A concrete sedimentation basin will be constructed near the power plant to receive excess condensate from the plant cooling towers. Approximately 1.1 Km (2/3 mi.) of new road will have to be constructed.

a. Well Pads

One well for the SMUD Unit 1 project has been completed from one existing drillsite. Complete development of the field for initial start up of SMUD Unit 1 will require the drilling of an additional nine or more wells from one existing and four proposed multiple well pad sites. The existing and proposed drill pad sites are indicated on Exhibit "F" Proposed Locations and Pipelines - Appendix 2.

Each well site will require construction of a level pad of about 4,000 square meters (43,000 square feet) with a drainage system and an adjacent waste sump with a capacity of about two to six million liters (1/2 to 1-1/2 million gallons).

Pad sites have been selected to take advantage of existing topographic flats or ridge lines.

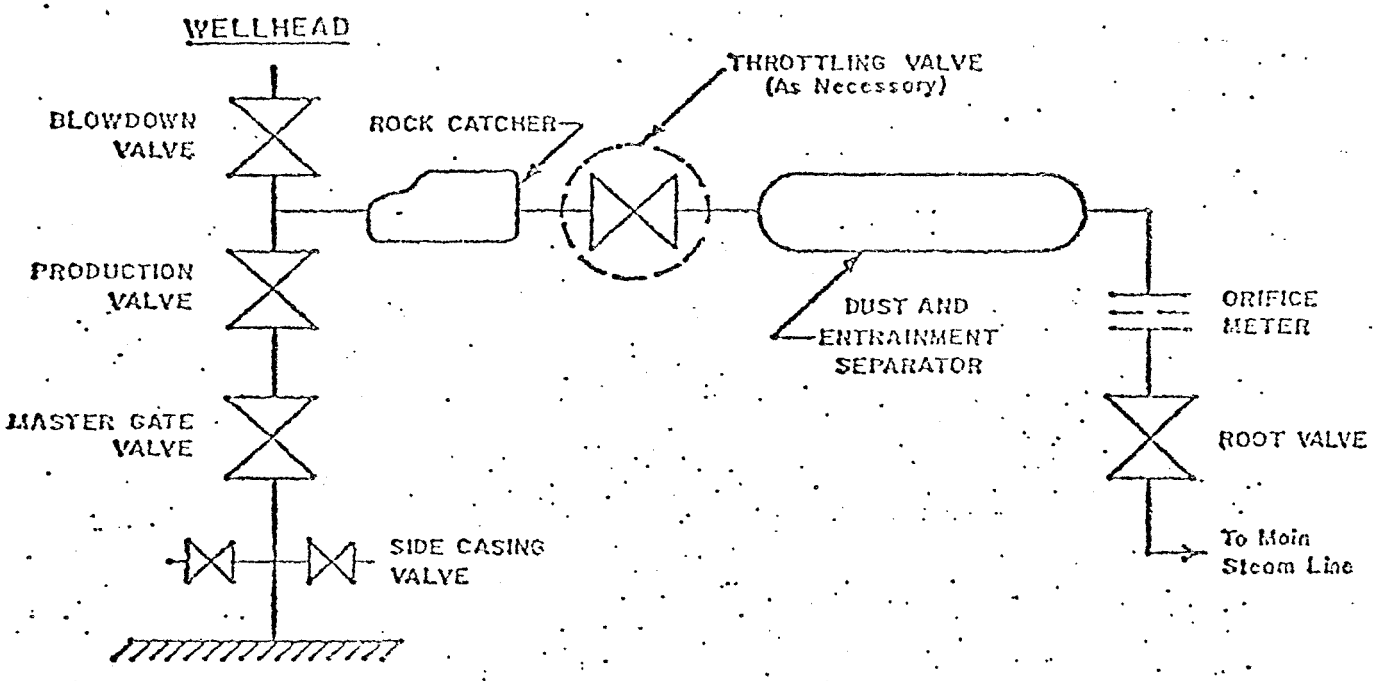
b. Access Roads

A minimum amount of new road construction will be required to provide access to the most westerly drill pad site. Existing roads between PGandE plant sites provide excellent access to the project area.

c. Steam Supply Pipeline System

Steam will be carried from the wells to the power plant in insulated steel pipelines supported above ground by drilled, cast-in place concrete piers. The pipeline system is designed to provide a steam supply of not less than 4.5×10^5 Kgs (10×10^5 pounds) per hour at 7 Kg/cm^2 (100 psig) and 170° C (340° F) at the power plant inlet. The size of the pipeline increases as required by steam volumes from a minimum at the well head to a maximum for the main trunk line at the power plant inlet. Exact pipeline sizes will be determined after the design criteria have been established.

The pipeline collector system (Exhibit "G" page 8) for each well includes a well head master and production valves, rock catcher (where necessary), rock muffler (where necessary), well head throttling valve, well head separator, well head meter run with orifice flange, and a well head isolation (root) valve. The collector system from the well head to the isolation (root) valve will be designed to withstand maximum well head shut-in pressure and temperature of 34 Kg/cm^2 (490 psig) and 240° C (465° F). A review of existing systems may indicate changes in the system which will be incorporated in the Plan of Production Operation.



TYPICAL WELL PAD COLLECTER SYSTEM

(SCHEMATIC)

EXHIBIT "G"

The main pipeline system from beyond the well pad collector to the plant inlet includes two master clean up separators (Exhibit "H" page 10) on either side of the plant inlet line, a series of automated steam relief valves which direct steam to a rock muffler silencer during power plant outages and a series of 13 Kg/cm^2 (180 psig) rupture discs located at strategic points along the line to provide for the safety and integrity of the system. The main pipeline beyond the well pad collector system will have a normal operating pressure of 9 Kg/cm^2 (125 psig).

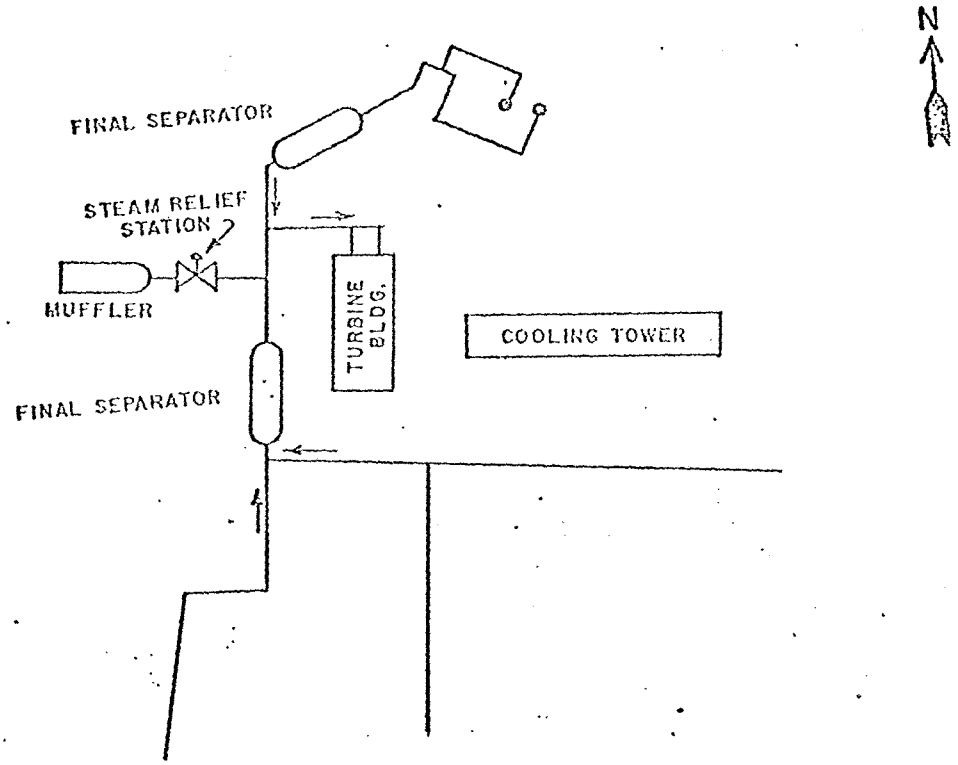
A condensate collector system will parallel the main pipeline and collect all steam emissions and condensate downstream from the well flow meter and exhaust into the reinjection system.

Steam transmission line routes are generally selected as the shortest distance to the generating unit, thus minimizing heat and friction loss. However, the layout of the pipeline system is somewhat dictated by the terrain of the rugged area. For ease of maintenance, routes will follow road alignments wherever possible. Turns and changes in elevation required by the rugged terrain offer some advantages in helping to provide relief for pipe stresses and anchor loads. Areas of active slope instability are avoided wherever possible. A low profile has been emphasized to reduce visual impacts.

Pipeline segments will be sized on the basis of pressure drop and steam velocity. Pressure drops are in the order of 0.01 Kg/cm^2 (0.15 psig) to 0.02 Kg/cm^2 (0.25 psig) per 30 meters (100') of equivalent pipe length resulting in total pressure drops between the well head and plant inlet of 0.35 Kg/cm^2 (5 psig) to 2.1 Kg/cm^2 (30 psig). Steam velocity varies from 30 meters/sec (100 fps) to 75 meters/sec (250 fps) with a 45 meters/sec (150 fps) velocity being the most desireable from the standpoint of minimizing noise levels and condensate losses.

Experience at the Geysers Field has proven pipe fabricated from low carbon steel such as ASTM A53, Grades A or B or piping of equal composition, to be highly satisfactory for steam transmission line. Internal corrosion of pipe used to carry steam at the Geysers has not been a problem. Insulation, used to minimize heat losses, has proven to be very effective in protecting external pipeline surfaces. Because of its longer life and its ability to be reused after removal for pipeline repairs, aluminum has proven to be the most effective material for use in covering the pipeline insulation. A colored external surface which blends with background vegetation is to be used to reduce visual impacts.

Pipewall thicknesses vary in range from 0.64 cm to 1.3 cm (1/4" to 1/2") in accordance with the ANSI B31.1 Power Piping Code, current edition. Stresses in pipeline material have also been designed to be within the limits as specified by the ANSI B31.1 Power Piping Code, current edition. The temperature of the pipeline from an extreme cold condition to an extreme hot condition ranges from about -10° C (14° F) to 205° C (400° F) which can result in a measured movement of about 3.2 cms (1-1/4") per 30 meters (100') of lineal pipe.



PLANT COLLECTOR SYSTEM
(SCHEMATIC)

EXHIBIT "H"

DRWG NO 58-1F03-60-59

This expansion produces the forces which require the anchors for holding the pipeline within its prescribed alignment. Concrete supported steel piers will vary in size from 20 cm (8") to 75 cm (30") in diameter and will be set at an average depth of three meters (10'). Supports will be spaced about 10 meters (33') apart. Depending on conditions at each pier location; one of the following supports will be provided:

1. Solid Anchor
2. A one direction sliding plate
3. A two direction sliding plate with limiting devices for lateral movement, or
4. A free floating support which allows both unlimited horizontal and vertical movement of the pipeline.

The rigid anchor points will be placed at about 150 meter (500') intervals at locations considered to be reasonably stable. Where forces are expected to be too great, expansion loops are provided to relieve the excess stress which might result. Earthquake and wind forces will be factored into the final pipeline design.

Valves selected for service in the steam gathering system will have cast steel bodies with stainless steel trim to protect against corrosion from exposure to minor amounts of hydrogen sulfide. Slab gate valves, such as the WKM Power Seal Type, or equivalent, are to be used at the well heads. Isolation (root) valves are to be typical gate valves with rising stems. Small valves of 5 cm (2") and under are to have forged steel bodies with stainless steel trim and stems.

Each well head collector system will be equipped with an automated throttling valve which may be actuated by a central control system. A feasibility study is being conducted to confirm if a central control system is warranted and also to determine if the Unit 13 and Unit 16 systems can be extended to SMUD Unit 1.

Exhibit "F" - Proposed Locations and Pipelines - Appendix 2, indicates the location of the proposed pipeline gathering system.

d. Condensate System

A concrete sedimentation basin will be installed near SMUD Unit 1 to function as a particulate sedimentation basin for excess condensate from the Unit 1 cooling towers. The basin will be equipped with automatic level sensing devices set to indicate alarm conditions at specific high water levels. The control devices will be of the "fail safe" type and powered by an uninterrupted power source.

Excess condensate will be piped to an, as yet, undesignated well for reinjection into the geothermal reservoir. The pipeline will be constructed of flanged, epoxylined, steel pipe elevated above ground and when possible parallel to the steam pipeline. The line will be sized to accommodate the maximum cooling tower outflow. The pipe will be rigidly supported by steel piers set in concrete.

8. Protection of the Environment

a. Emergency Contingency Plans

Contingency plans for (1) Emergency Accidental Spills and Discharge Control Procedures, (2) Emergency Fire Control Procedures, (3) Hydrogen Sulfide Contingency Plan and (4) Blowout Contingency Plan were forwarded with cover letter dated July 26, 1977 and are on file at the USGS Office of the Geothermal Supervisor, Menlo Park, California.

b. Soil Erosion

The Environmental Impact Analysis "The Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, California" Ekoview February, 1975 overlaps the project area. The Report states that according to Jackson (1972) natural or geologic erosion rates for soils formed on Franciscan Formation in this very active tectonic zone are among the highest known in the world. Soils on the Leasehold are identified by the Ekoview Report as Josephine, Maymen and Hugo Series. All three of the soils are referenced by the USDA Soil Conservation Service 1972, as having high permeability, good drainage, high susceptibility to erosion and fair to poor suitability for vegetation.

Care will be taken at the project site to minimize the potential for erosion and disturbance of natural drainage. The outer limits of the entire area to be disturbed will be staked for field inspection prior to commencement of any construction activities. Vegetation will be cleared and earthwork and installation of culverts and drainage ditches will be done pursuant to specifications as provided by a qualified Civil Engineering firm. On completion of construction all outer fill slopes will be dressed and compacted by rollers or by walking with a crawler tractor. Vegetation will be re-established on all fill slopes and appropriate cut slopes pursuant to recommendations of a qualified vegetation consultant acceptable to the USGS, Menlo Park, and BLM, Ukiah District Office. Revegetation will take place prior to the wet season immediately following completion of construction activities.

c. Surface and Ground Water

All construction will be completed pursuant to specifications for protection of ground water resources. The waste discharge sumps at the well sites will be constructed with a 61 cm (24") thick impervious clay liner compacted to insure a maximum permeability of 1×10^{-6} cm/sec. (0.4×10^{-6} inches/sec). Subsurface ground waters will be further protected by casing and cementing procedures proposed in the Application to Drill (Form 9-331C) and approved by the office of the Geothermal Supervisor, Menlo Park.

Big Sulphur Creek drainage area supports several tributaries throughout its course which drain the project area. The northerly portion is drained by the headwaters of Cobb Creek, a perennial stream. The southwesterly portion is drained by two unnamed perennial creeks which flow into Big Sulphur Creek above its confluence with Hot Springs Creek. A small ephemeral stream drains the southern portion of the project area and flows westerly into the most easterly unnamed creek

which drains the southwesterly portion.

Drainage of the northeast corner of Section 28 flows into Anderson Creek and ultimately into Putah Creek which forms a part of the watershed basin for Lake Berryessa.

The potential for stream pollution will be minimized by construction of earthern berms at appropriate locations along the drill pad sites which will direct any accidental spillage of oil and grease from operating facilities into the waste disposal sumps. Waste disposal sumps will be constructed with capacities to accomodate all of the liquid wastes from drilling operations plus the maximum precipitation which could be expected to fall within its area. The sumps will be operated with a minimum 91 cm (36") of freeboard above the liquid level at all times.

d. Fish and Wildlife

Direct impacts to resident wildlife will be from the alteration or removal of habitat for the construction of well pads, pipeline installation, and new access roads. Displacement or elimination of the smaller and more sedentary forms of wildlife will be the most significant impact. The affected area will be a small fraction of Lease Unit No. 7 West CA 1862.

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

Observations 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 of the area for all of these birds appears to be for foraging. No nesting is known to occur on or adjacent to subject lease.

e. Air Quality and Noise

The potential impacts of the project on air quality are: (1) increased suspended particulates from road and pipeline construction, vegetation removal, and vehicular traffic, (2) particulates generated during air drilling, and (3) production of hydrogen sulfide (H_2S) during drilling, testing and producing. The particulates from construction activities will be mitigated by the exercise of good engineering practices and by the wetting of problem dust areas when necessary. Particulates generated from drilling will be abated by use of injected water and a cyclone separator/muffler. Potential impacts from the production of H_2S will be mitigated as required by the Sonoma County Air Pollution Control District. A Hydrogen Sulfide Contingency Plan was forwarded with a cover letter dated July 26, 1977 and is on file at the USGS office of the Geothermal Supervisor, Menlo Park, California.

Potential environmental impacts by increased noise levels exist from the various construction and drilling equipment and from testing of the wells and pipeline. 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. Altogether noise from drilling operations, even though of only 60-90 days duration, will be abated to a level of 65 dB(A) at a distance of 0.80 Km (0.5 miles). Noise levels during pipeline testing (blowdown) will not exceed Ldn 55 dB(A) at locations approximately 1.7 Km (1 mile) away during each 12 hour test period. A "Report of Noise Associated with westside portion of Unit 13 blowdown" prepared by Consultants in Engineering Acoustics June 12, 1979 was filed with the Plan of Development Operation, Geysers Power Plant 16, on August 8, 1979. This report indicates that the sound levels from blowdown noise at Anderson Springs, approximately 1.7 Km (1 mile) away, were well below the land use permit criterion of an Ldn of 55 dB(A).

9. Methods of Disposing of Waste Material

Waste disposal for the project will be in accordance with methods described in Supplement III to the Plan of Operation for Lease Unit No. 7 CA 1862 submitted April 23, 1979.

C. Plan of Injection Operation

At this time, the well to be selected as an injection well is not known. Details regarding the well selected as an injector and exact line sizes will be provided in the Plan of Production to be submitted at a later date. Condensate from producing wells will be collected through the collection line to be installed adjacent to and with the main steam transmission pipeline system. The collection line will carry the condensate from production wells into the main injection line or the sedimentation basin at the power plant site along with the condensate from the cooling tower. Condensate from the sedimentation basin will flow through a non-corrosive line to a point just beyond the outer perimeter of the power plant site and an epoxy coated line from that point to the well head. As described previously, a fail-safe, two-stage alarm system operated by an uninterruptable power supply will protect the condensate system from overflow.

The condensate system will be operated in compliance with Waste Discharge Requirements adopted by the California Regional Water Quality Control Board, North Coast Region.

D. Environmental Concerns

1. Regional and Local Geology

The project area is located in the central Mayacmas Mountains of the California Coast Ranges. These ranges are known for their complex geology, active and potentially active faulting, rugged terrain, highly erodible soils, and widespread landslide conditions.

The central Mayacmas Mountains have been mapped by R. J. McLaughlin (1978) as a structurally complex, southeastward-plunging anticline (regionally upfolded and tilted mass of rock). The eroded core of this structure consists of late Mesozoic sedimentary, igneous and metamorphic rocks of the Franciscan Assemblage. Sedimentary rocks known as the Great Valley

Sequence, in places, overlie the Franciscan core rocks but are in part contemporaneous in age. Large scale thrust-faulting along the Coast Range thrust has placed the Great Valley Sequence over the Franciscan Assemblage. This thrust fault is characterized in most areas by the occurrence of serpentinite or other basic intrusive rocks along the base of the fault.

North and east of the main Geysers area, rocks of the Franciscan Assemblage are unconformably overlain by Tertiary-Quaternary volcanics of the Clear Lake Volcanic Series. West of the Geysers, Franciscan rocks are unconformably overlain by Tertiary and Quaternary sediments. Throughout the Coast Range of California, the Franciscan Assemblage has been severely folded, fractured and faulted producing an extremely complex mixture of rock types. Serpentinite and basic intrusive rocks are common throughout the assemblage. The distribution of these bedrock units in the vicinity of the site is shown on Exhibit "C", Geologic Map - Appendix 1.

The leasehold is entirely underlain by rocks of the Franciscan Assemblage of Jurassic to Cretaceous age and by rocks closely associated with the Franciscan Assemblage. Regionally metamorphosed graywacke sandstone is the most prevalent rock type, underlying approximately 70% of the area. It occurs principally in the northern and eastern portions of the area, but is interbedded with greenstone in the western portion. Much of the graywacke mapped in the central portion of the area, occurs as "tectonic blocks" within a melange unit. Serpentinite, melange, and metagreenstone underlie approximately 30% of the area, principally in the western portion.

Melange occurs in a narrow band trending northwest across the central portion of the area. There are numerous inclusions or tectonic blocks of metagraywacke, greenstone and blueschist within the melange. The melange is in fault contact with metagraywacke to the northeast and southwest. A narrow northwest trending band of serpentinite and melange also occur along the eastern margin of the area. Metamorphosed ultramafic rock and associated serpentinites and greenstones occur along the western margin of the area. The rock unit as mapped by R. J. McLaughlin (1978) extends northwest along most of the producing trend of the Geysers. In general, the contacts between most rock units within the area are ancient faults. These faults, although not sources for future seismic activity, have in many instances produced severe shearing and deformation of the rocks immediately adjacent to them and have provided conduits for hydrothermal fluids which have altered the rocks in their vicinity. This hydrothermal alteration is apparent on the western portion of the lease.

Shale units in Franciscan terrain are locally common but not often seen in outcrop because their fractured and sheared condition tends to accelerate the weathering process to produce an obscuring layer of soil. The relative scarcity of outcrops in some of the areas mapped as underlain by metagraywacke and melange suggests that shale may be a significant constituent within these units. Conglomerate units are also known to occur within graywacke and metagraywacke units. These are observed in outcrop in northeast portion of the area.

2. Potential Geological Engineering Hazards

a. Seismicity

The Geysers KGRA is located in a region known to be seismically active. The San Andreas, Healdsburg-Rodgers Creek, and Maacama Faults are the closest known active faults within the region which are capable of pro-

ducing damaging ground shaking within the study area. They are located 53 km (32 mi), 20 km (12 mi) and 13 km (8 mi) southwest of the study area, respectively.

There are no known active faults through or closely adjacent to the project area. The Collayomi Fault, which may be active, located about 4 km (2.5 mi) east of the project area, would generate the greatest ground shaking due to its proximity.

The largest historically recorded earthquake which affected the area was the 1906 San Francisco Earthquake which occurred along the San Andreas Fault. Lawson (1908) indicated Modified Mercalli ground shaking intensities of VI in the vicinity of the project area as a result of this event. Little or no damage was reported to communities in the nearby region. However, the region was sparsely populated at that time and it is possible that some shaking effects may have gone unreported.

The Healdsburg-Rodgers Creek Fault was the source of the 1969, Magnitude 5.6 and 5.7 Santa Rosa Earthquakes. A Modified Mercalli ground shaking intensity of V was reported in the vicinity of the Geysers as a result of this earthquake (U. S. Department of Commerce, 1971). Little or no damage was documented.

b. Landslides

Based on field mapping and aerial photo study done by Harding-Lawson Associates, numerous landslides of varying dimensions and degrees of activity were identified within the area. The location of these slides are shown on Exhibit "C", Geologic Map - Appendix 1. The majority of these landslides occur in the southern portion of the area. Numerous large, apparently inactive landslides are associated with the northwest trending melange belt which occurs in the central and eastern portion of the area. The association of landslides and melange terrain is common throughout the Geysers area and is due primarily to the low strength of the highly sheared melange materials. Construction of drill sites in the area of the melange will be done so as to avoid these slide prone areas for the location of well pads.

Along the western portion of the area, hydrothermal alteration of serpentinites and metamorphosed ultramafic rock has produced a large, active slide in the vicinity of proposed well pad location CA 1862-A (Exhibit "F", Proposed Locations and Pipelines - Appendix 2). This slide has been avoided for the location of the well pad. Presently, a detailed geotechnical investigation of all drill sites in the vicinity of landslides is being conducted by Harding-Lawson Associates. The results of this study will be filed as an addendum to this Plan of Development Operation.

Soil creep (the very slow downhill movement of soil, probably a few millimeters to centimeters per year) appears to be very low within the area. This seems to be due to the very dense vegetation characteristic of much of the area. Vegetation and its root structure tends to hold the soil in place, thus, limiting the amount of downslope movement.

3. Hydrology

a. Surface Water

The project area is part of the Big Sulphur Creek drainage area which supports several tributaries throughout its course. These are mostly ephemeral streams having significant water flow only during the winter and spring months; by late summer most are dry. On the north side of Big Sulphur Creek, Cobb Creek, Hot Springs Creek, and two unnamed creeks within a mile southeast of Hot Springs Creek are perennial; on the south side, three unnamed creeks, located between the Geysers resorts and the confluence of Hot Springs Creek with Big Sulphur Creek and Truitt Creek, are perennial. Tributaries almost uniformly have a northeast-south-west trend, the exceptions having a more northerly course. Thus, they are normal to the direction of Big Sulphur Creek and the structural grain of the region.

A small area in the northeast corner of Section 28 drains into Anderson Creek and ultimately into Putah Creek which forms a part of the watershed basin for Lake Berryessa.

Steep slopes and low substrata permeability offer a limited reservoir for storing precipitation. Underlying rock is generally not conducive to infiltration from percolating soil water. During the rainy period, short, ephemeral streams augment local stream flow causing runoff to be highly responsive to rainfall amounts. As a result, waterways are subject to rapid increase and decrease of flow rates.

b. Ground Water

No regional groundwater aquifers of significant yield have been reported to date in the underlying rock formation of the Mayacmas Mountains in the Geysers area. Franciscan rocks are generally classified as non-water bearing. They are considered impermeable except along fracture zones which locally yield small quantities of water to springs and wells. The presence of cold springs and seeps indicates some near surface groundwater. Springs and seeps are particularly common in landslides. Significant groundwater resources are not known to exist on or in the vicinity of the project site. All construction, however, will be completed pursuant to specifications for protection of groundwater resources.

4. Meteorology

Climate of the Geysers Region is a mild two-season type with wet winters and dry summers. Most precipitation occurs October through May, with rain predominating. The dry season usually occurs June through September, and is long enough for soil moisture to be depleted producing dry range lands before fall rains commence.

The complex terrain of the Geysers Region is a major factor affecting local climate. Interplay between terrain and climate is reflected in data from the area's several meteorological monitors.

The Mayacmas Mountains ridge deflects incoming marine air, thus producing temperatures within the Geysers region relatively continental in character. Interpolating from Elford (1964), temperature pattern at the project site is:

January mean minimum temperature	0°C (32°F)
January mean maximum temperature	13°C (55°F)
Lowest observed temperature	-10°C (14°F)
July mean maximum temperature	30°C (86°F)
July minimum temperature	9°C (48°F)
Highest observed temperature	43°C (109°F)

Average relative humidity at the Geysers ranges from 13% during the driest months up to 80% in the winter.

Potential annual moisture utilization in the project area is about 75 cm (30"). Stored soil moisture usually is depleted by early June.

Wind speed generally increases with elevation. At elevations below 300 m (1000') annual average wind speeds, excepting calms, are 3 to 5 kph (2 to 3 mph). At elevations of about 760 m (2500') average speeds range between 6 and 10 kph (4 to 6 mph). At and above 915 m (3000') elevation, the average exceeds 16 kph (10 mph).

Frequency of calms (winds less than 2 to 3 kph) (1 to 2 mph) varies from 55% at stations below 610 m (2000'), to less than 0.3% at exposed elevated peaks. At lower elevation stations, highest frequency of calms is in winter, and lowest in summer.

Directional frequency distribution of local wind flow is more complex. At higher elevations (915 m) (3000'), yearly average directional frequency is either from the NE $\pm$ 45° or SW $\pm$ 45° nearly all the time. This bimodal distribution is observed in all seasons, but with the NE quadrant slightly favored in winter, and the SW quadrant strongly favored in summer.

At lower elevations, local terrain effects become increasingly important in determining directional distribution. These effects are of two types:

Channeling of moderate and strong flows within valleys and around obstacles, and buoyancy driven slope flows consisting of upslope flow over sun heated surfaces and downslope nocturnal flow. Low elevation wind frequency distributions also tend to be bimodal, except that preferred directions are defined by local topography and, thus, vary considerably from site to site. With the exception of low elevation stations located in valleys oriented NE-SW or on slopes with a fall line downward to the SW, very little similarity is found between directional distribution aloft and that at lower elevations.

As implied by the rate of buoyancy mentioned above, the bimodal distribution frequently observed at lower levels is also diurnal, (i.e. each of the preferred directions is generally limited to a particular time of day). The exact local variation depends on slope orientation on or below which the monitoring station is located. At a low elevation site on or below eastward facing slopes and not in a N-S oriented valley, the typical sequence of events is: Predawn westerlies (downslopes), midmorning easterlies (upslope), and afternoon through evening southwesterlies (sea breeze).

On westward facing slopes, early morning flows are normally easterly (downslope) becoming westerly (upslope) in the late morning, followed by more southwesterly flows through evening (sea breeze). Downslope, drainage flows are best developed in winter, and upslope and sea breeze flows are strongest and most frequent in summer.

Directional frequency of high elevation flows at the former meteorological station nearest the project area (SRI-2, was located 0.8 km (0.5 mi) to the southeast has the typical NE-SW bimodal distribution and seasonal variability. SRI-2 was removed in February 1979 after three years of monitoring. In summer, frequency distribution is diurnal, with northeasterly winds observed only between midnight and noon. In winter, no significant correlation between NW flows and time of day can be established.

5. Soils

The Environmental Impact Analysis "The Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, California", Ekoview, February 1975, overlaps Federal Lease Unit No. 7 West CA 1862. Soils on the Leasehold are identified by the Ekoview Report as Josephine, Maymen and Hugo Series. All three of the soils are referenced by the USDA Soil Conservation Service 1972, as having high permeability, good drainage, high susceptibility to erosion and fair to poor suitability for vegetation.

6. Biota

a. Fauna

According to the Environmental Impact Analysis, "The Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, California" Ekoview, February, 1975, a wide variety of habitat types are found within the leasehold. These include rock balds, chamise, live oak-buck brush-manzanita, silk tassle-manzanita-oak, bay madrone-canyon oak woodland, digger pine-shrub, knob cone pine woodland, and canyon oak-fir-pine woodland.

The Ekoview report, which overlaps and includes the area of Federal Lease Unit No. 7 West CA 1862 within its baseline collection boundary, identifies two amphibian species, ten reptile species, thirty bird species, and twenty-one mammal species as recurring within the chaparral habitat similar to the project area.

The only threatened or endangered wildlife species known to exist within the project area is the peregrine falcon (Falco peregrinus). The peregrine falcon has been observed flying in the vicinity of the project area on several occasions. The "Report of Survey to Determine the Status of the Peregrine Falcon (Falco peregrinus anatum) in the Geysers area (Cobb Mountain) of Sonoma and Lake Counties", Dr. Kenneth E. Stager, PhD. April 25, 1977, failed to disclose any indication of the presence of the American peregrine falcon from February 2, 1977 through March 31, 1977 and concluded that "Geothermal development in the Cobb Mountain area is exerting no detrimental impact upon the welfare of the endangered American peregrine falcon".

Additional quantitative studies related to the wildlife habitat of Federal Lease Unit No. 7 West will be completed prior to submission of a Plan of Production and pursuant to 30 CFR 270.34 (k).

Impacts

A small percentage of the leasehold will be lost as habitat as a result of the proposed pipeline access road and well pad construction. Wildlife species directly impacted will be the smaller, more sedentary species such as fence lizards, salamanders, small birds such as wrentits and rufoussided towhees, and small rodents. Habitat for a few individuals of these common, widespread forms will be lost to the population. Those species which are adapted to open or "edge" situations may benefit because of their ability to utilize fill slopes and road sides. These would probably include deer mice, mourning doves and small birds that feed upon grass and weed seeds. Habitat and wildlife corridor disturbance from pipeline construction should be minimal. Cattle continue to graze in areas where pipelines have been constructed and to walk under raised pipes. Deer and other mammals would be expected to do the same.

Noise levels and human disturbance will increase, especially during site construction. This is expected to cause minor and in some cases only temporary reduction in habitat useage.

Noise and disturbance from drilling operations may have some adverse impact on fauna by discouraging the use of adjacent habitat. During the 60 to 90 day period required for drilling a well, the maximum noise levels expected at the edge of the pad (about 50 m (165') from the rig) are 75-85 dBA. At 200 to 250 m (650 to 820') from the rig, noise levels should be well below 65 dBA. Between the latter distance and the edge of the pad, some reduction in bird nesting and feeding activities may occur but other animals will probably be unaffected. Well cleanout and production testing may produce noise levels of 85 to 115 dBA at the edge of the pad, depending on the noise control technology employed. The behavioral responses of wildlife to noise of this intensity are not well understood but, since it would be of brief duration, no serious impact is expected.

During operation of a steam supply field, ambient noise levels in wildlife habitats adjacent to development generally range from 45 to 65 dBA. On rare occasions, large amounts of steam may be vented from one or more wells. Noise levels may reach 100 to 110 dBA for periods of a few hours. Because of the short duration of such exposures, no serious impacts on wildlife are expected.

The potential exists for accelerated erosion, especially during site construction. This could result in the siltation of Big Sulphur Creek drainage with deleterious effects on the fishery and benthic invertebrate fauna. The magnitude of these impacts depends upon the success of mitigations such as revegetation.

Accidental spills of drill wastes, condensate, petroleum and other fluids may occur which can cause adverse impacts on fish and aquatic life if they enter streams. The bentonite clay in drilling mud is of particular concern as are toxic materials and heavy metals (arsenic and mercury) found in geothermal fluids.

Since fauna is dependent upon vegetation for food and cover, damage to vegetation from development will affect wildlife indirectly. Several conditions may lead to damage. Settling of dust from roads, construction work, and particulate emissions on leaves may cause a decline in vigor and productivity. Increased humidities and release of biosensitive materials such as boron from steam venting may cause a decline in vegetation. Direct venting of steam can cause damage and death to adjacent vegetation.

Mitigations

Riparian corridors and water sources such as streams and springs are of critical importance to wildlife. The effective mitigation is to avoid development whenever possible in these areas.

Large conifer snags and other dead, hollow trees should be protected because of their importance as nesting and perching sites for many bird species.

Erosion potential should be reduced by exposing as little surface area as possible during construction and grading. Steam pipelines will be aligned to the maximum extent possible along access roads to reduce clearing requirements. Once welding operations are completed, the nine meters (30') clearing initially required along pipelines will be revegetated with native grasses.

Other mitigations that will help to reduce or eliminate the impacts of the development on fauna are:

- Toxic material control through careful construction of sumps and maintenance and operation of condensate pipelines.
- Dust control by sprinkling work sites and roads with water or other acceptable dust retardant.
- Particulate emission control by use of water injection in the cyclonic muffler during air drilling and production tests.
- Noise control by circulation of steam discharges through effective mufflers.
- Venting damage control by directing steam away from vegetation, and by erecting temporary shields between the steam source and vegetation where necessary.

b. Flora

The flora of Federal Lease Unit No. 7 West is an aggregation of communities that are common in the Mayacmas Mountain Range. These communities have been described in detail elsewhere (Neilson, et al). In general, these communities reflect changes in soil types and soil parent material, but their composition is usually modified by slope aspect and to some extent disturbance.

Where serpentine is highly concentrated, barrens occur which support sparse communities of serpentine jewel flower, naked stemmed buckwheat, snow mountain buckwheat, birds foot fern, and occasionally Solano milkweed.

Graywacke derived soils have a much wider range of communities, although, ecotones are common where serpentine underlies graywacke at relatively shallow depths.

Brushlands occur in large stands over much of the study area. Exposure and soil type are critical factors in segregating brushlands. South and southwest facing hillsides on shallow graywacke soils support chamise communities. Pure chamise occurs on the hottest, driest and thinnest soils. As soil mantle increases, buckbrush, Eastwood's manzanita and mountain mahogany become codominant. Ridge tops also support silktassel brush. North facing slopes support shrubby live oak communities and where soils are best developed some of these eventually develop into oak woodlands or Douglas fir forests depending on fire frequency. Shrubby live oak communities vary considerably in composition but

characteristically include Eastwood's or big manzanitas, wavy leaved ceanothus, coffeeberry, mountain mahogany and buckbrush. Deer brush, California nutmeg, bay and madrone also occur on more moist sites.

Knobcone pine woodlands appear to occur mostly in response to frequent burning and seem to be more or less independent of soil type and exposure. They have a wide range of associates depending on pre-burn communities. Closed stands contain Eastwood's manzanita as an understory.

Rare and Endangered Plant Species

A survey of rare and endangered plant species has been conducted by Aminoil's revegetation consultant, Ralph Osterling, during the period April to June, 1979. The ground area covered by the survey was agreed upon by BLM and USGS personnel and is indicated on the Map Exhibit "I" by the green shaded portion. A copy of the report will be forwarded under separate cover to the USGS Office of the Geothermal Supervisor, Menlo Park, California, when it is completed about October 31, 1979.

Potential adverse impacts on flora from the project include:

- Vegetation removal with potential concomitant increases in soil erosion, indigenous nutrient loss, watershed effects, and wildlife readjustments.
- Direct scalding or condensate adsorption and absorption of boron and other salts into plant tissue.
- Accumulation of salts and sulfur compounds from H_2S emissions, condensate water, etc, in plant tissues.
- Increased potential of wildlife from human access and activity.

Mitigations

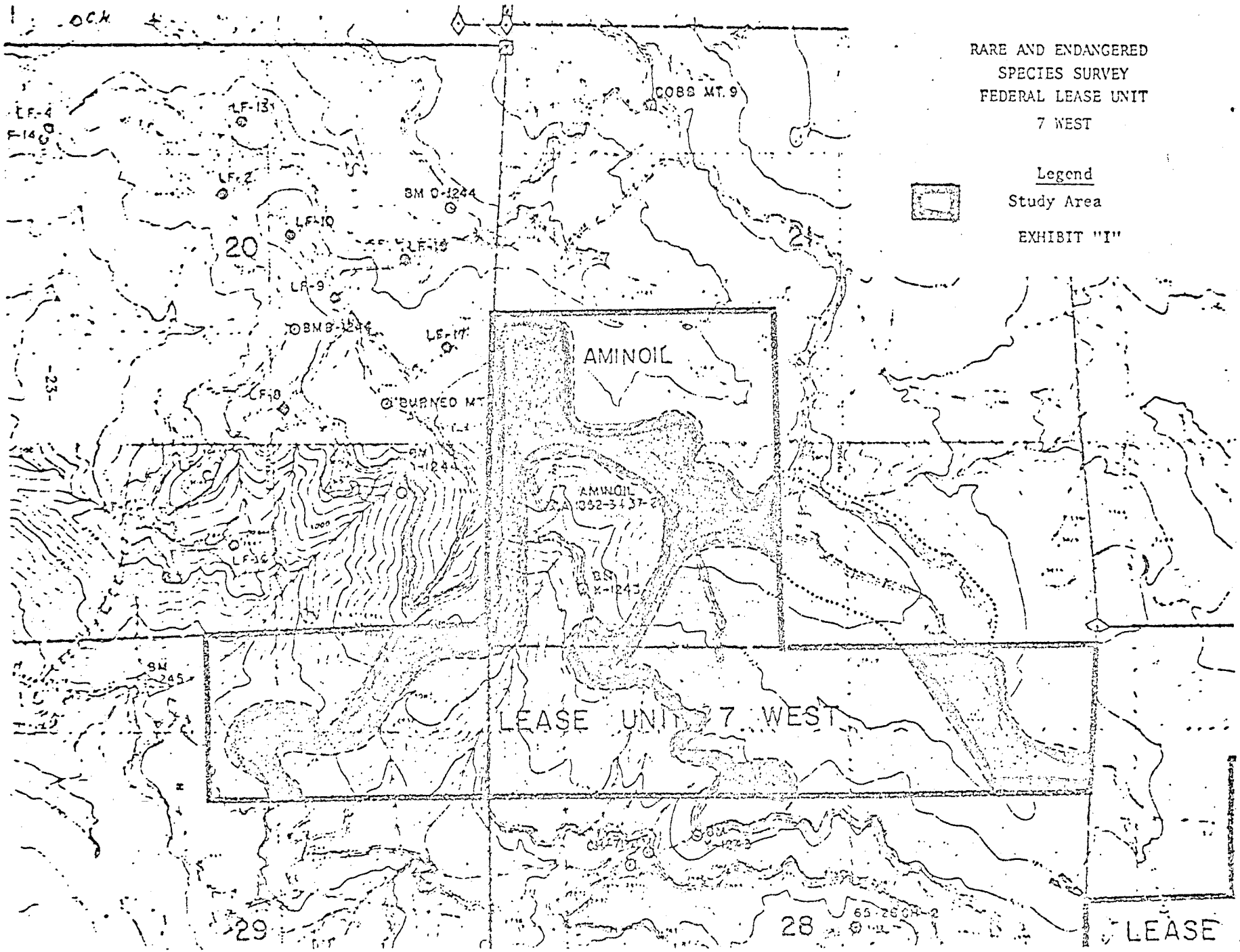
Mitigations applying to vegetation to lessen the impact of development include avoidance whenever possible of critical areas (including steep slopes, populations of species of special concern, and mature stands of forest trees), re-establishment of vegetation on denuded areas, or removal of above ground portions without destroying the regenerative crown along the pipelines.

Populations of rare or endangered species and most species of special concern will be avoided or appropriate mitigation measures will be followed where their presence is positively established. Pipelines will follow existing roads where possible and hence avoid new disturbance that will increase overall impact.

Re-establishment of Vegetation

Full re-establishment of native communities following geothermal development is unlikely where ground surfaces are disturbed. Ten years of testing and general application in the Geysers KGRA, indicates the establishment of hardy perennials and a number of native annuals and weeds has had the greatest success. Both native and non-native species have been successfully established on some Aminoil properties by making a careful selection of species based on their adaptability and by providing professional care over the first critical year.

Graywacke material is very poor nutritionally and has very little water holding capacity. Josephine, Maymen, Hugo and similar soils do better in support of revegetation and the establishment of native shrubs partially because they are more common on north and east facing slopes that are not so warm and dry.


RARE AND ENDANGERED
SPECIES SURVEY
FEDERAL LEASE UNIT
7 WEST
Legend
Study Area
EXHIBIT "I"
COBB MT. 9
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AMINOIL
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AMINOIL
LEASE UNIT 7 WEST
20
29
28
LEASE

Almost no results can be expected on serpentine soils, which are inherently poor and coarse. A few native species can be re-established such as squirreltail grass and buckwheats. However, even natural communities are sparse and growth is usually measured in decades rather than years.

Since the Forest Service requires a 9 meter (30') cleared path for fire protection along pipeline routes, revegetation can be effective only by allowing crowns of shrubs to resprout and then maintain a close pruning program to restrict growth to 30 cm (12"). An alternative method is to reseed with native grasses or acceptable mixes that include: Blando brome, Idaho fescue, California fescue, red brome, wooly sunflower (Eriophaylum lanatum), and pubescent wheat grass.

Ethnobotanical Species

Species that were commonly used for food and medicinal purposes by Indians of the area do occur on the study area. Pines, particularly Digger and yellow pine, provided nuts, however, neither species is particularly important on the leasehold nor uncommon in these mountains. Similarly, several medicinal plants are known from the area: Yerba Santa, Pitcher sage, and coyote mint. All are very common and need not be specially protected.

Torrent sedge and the bark of several trees and shrubs were used for fibers. As with the other species, all are common and widespread.

7. Cultural Resources

The "Archeological Assessment of Cultural Resources on Geothermal Leaseholds in Lake and Sonoma Counties, California, Burmah Oil and Gas Company" (now Aminoil USA), Ann S. Peak, Consulting Archeologist, October 1974, included the portions of Sections 21, 28 and 29, T11N, R8W, MDB & M, which make up Federal Lease Unit No. 7 West CA 1862. Results of that survey concluded that no archeological sites were located within the boundaries of Federal Lease Unit 7 West and that no impact on cultural resources would be expected by construction of geothermal facilities. The report was completed under Federal Antiquities Permit No. 74-EM-016 October 1974 and is on file with the Office of the Geothermal Supervisor, Menlo Park, California.

The Environmental Impact Report "The Geothermal Leasehold of Union Oil Company at The Geysers, Sonoma County, California" Ekoview, February 1975, overlaps and includes within the boundaries of its baseline data collection area the portion of Sections 21, 28 and 29 which comprise Federal Lease Unit No. 7 West. The archeological section of that report was completed by David A. Fredrickson, Department of Anthropology, Sonoma State University and failed to locate any archeological or historical sites within the proposed project area.

Field work for Cultural Resources Evaluation, which will supplement the existing studies including a paleontological investigation, ethnographic and historic overview, historic site inventory, inventory of native American sacred, religious and cultural sites and determination of any Native American Socio-cultural values associated with the project area, was completed in August 1979. The study is being done by the Cultural Resources Facility, Anthropological Studies Center, Sonoma State University, Academic Foundation, Inc. and a copy of the Final Report, which is expected in late October, 1979, will be forwarded upon receipt.

8. Current and Prospective Land Uses and Local Economy

The site vicinity is presently committed to geothermal development by County use permit. The nearest proved field, PGandE's Units 9 and 10 developed by Union Oil Company borders the Leaseholds to the northwest. Recreational uses such as fishing, hunting, hiking, etc. also occur. Mercury has been mined, but the 9 mines in the Geysers area, are inactive. Steep terrain, low fertility soils and limited water supply severely constrain potential land uses in the immediate area.

As was stated previously, in the section on "Steam Reservoir Adequacy" the Leasehold has productive wells on three sides; west, south and east.

The Leasehold is at a relatively remote location; the easternmost boundary being approximately 3 km (2 mi) from the nearest residential community, Anderson Springs. The Environmental Impact Analysis "The Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, California" Ekoview February, 1975, states that "According to the pattern of developers in the area about 70% of their personnel are drawn from indigenous sources. Hence the overall influence on direct population patterns is negligible, at least for some time to come".

E. Emergency Contingency Plans

Contingency plans for (1) Emergency Accidental Spills and Discharge Control Procedures, (2) Emergency Fire Control Procedure, (3) Hydrogen Sulfide Contingency Plan and (4) Blowout Contingency Plan were forwarded with cover letter dated July 26, 1977 and are on file at the USGS Office of the Geothermal Supervisor, Menlo Park, California.

F. Public Health and Safety

Project operations will be conducted in a manner which provides the maximum protection to the overall environment. Necessary precautions will be taken and public access will be restricted in areas where required to protect the public health and safety. Warning signs, fencing, barricades or other safety measures will be taken when and where deemed necessary.

Employees will be provided with portable sanitary facilities, bottled drinking water, sound pressure protective devices, a first aid facility and hard hats will be worn by all construction and drilling personnel while on location. Radio and telephone communications will be provided for emergency situations.

G. Environmental Data

A substantial amount of environmental baseline data now exists which would be applicable to the project area. A data review will be made and where necessary monitoring programs will be initiated and additional baseline data will be collected and submitted with the subsequent Plan of Production pursuant to 30 CFR 270.34 (k).

H. Schedule of Operations

Start of Construction (Drilling of wells under Plan of Development).	May, 1980
Completion of Construction	December, 1983
Start of Commercial Operation	January, 1984
Life of Project	30 years +