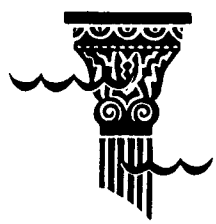
ENVIRONMENTAL IMPACT REPORT
CASTLE ROCK SPRINGS
GEOTHERMAL STEAM AREA
BURMAH OIL AND GAS COMPANY
LAKE COUNTY, CALIFORNIA

August 22, 1975



Atlantis Scientific

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PROJECT DESCRIPTION

SITE LOCATION

The proposed project site is located in the Castle Rock Springs area, County of Lake, California. The site lies approximately two (2) miles west of Highway 175 and south of Socrates Mine Road. The site encompasses seventeen hundred (1700) acres, of which 610 acres are on Bureau of Land Management land, 190 acres are in Sonoma County, and the remaining 900 acres are under Lake County jurisdiction. The location of the site and its precise boundaries are shown on the following maps. Figure 3 shows a drilling rig (a), valve (c) and well venting (B and D).

GENERAL DESCRIPTION

The Castle Rock Springs region of Lake County is the site of a large geothermal resource, consisting of steam under high temperature and moderate pressure, several thousand feet below the surface. The site is adjacent to a region known as "The Geysers", itself the scene of intensive geothermal development.[60]

Tapping the geothermal resource involves drilling wells to reach the subterranean steam, bringing it to the surface and conveying it via pipelines to an endpoint where the thermal energy can be utilized. The proposed industrial project is composed of thirty three (33) geothermal wells (13 existing, 14 on BLM land, 6 new on private land in Lake County), pad sites, roads, pipelines, and support facilities. Figure 1 shows part of the well operation.

The proposed project includes the drilling operations and their associated support activites and the installation and maintenance of transmission pipelines used to deliver steam. The project involves essentially 3 phases: (1) a drilling and testing phase, (2) a pipeline construction phase; and (3) a long term production phase.

The endpoint for steam delivery will be an electric generating plant to be constructed and operated by Pacific Gas & Electric, (PG&E) a public utility regulated by the California Public Utilities Commission (CPUC). Construction of that plant will require a separate Environmental Impact Report prepared by the CPUC.

SELECTION OF THE CASTLE ROCK SPRINGS SITE

There are relatively few known geothermal resource areas in the United States, and The Geysers/Castle Rock Springs area is considered to be one of the most productive, primarily because the steam found there is relatively

clean and non-corrosive.[129] The Geysers region has been heavily developed for geothermal operations, and generating plants located there have been supplying electric energy to PG & E for 15 years. Total generating capacity at existing PG & E geothermal plants is about 500 MW.[9]

Development has proceeded with relative speed at The Geysers because of the high quality and abundance of the geothermal resource. In addition, the steam was initially located relatively close to the surface, making drilling operations easier and less expensive.

With conventional fossil fuel costs rising and reserves becoming depleted, the search for alternative energy sources has been intensified. Especially attractive are those sources of energy located within the borders of the United States, and hence not subject to arbitrary embargo by another nation.

Thus, the successful development of The Geysers, which comprise only a fraction of the known geothermal province in the area, has attracted energy developers to surrounding sites. The Castle Rock Springs site is advantageously located for such development.

DESCRIPTION OF THE GEOTHERMAL PROCESS

A complete explanation of the geothermal process can be found in the Environmental Impact Analysis prepared by EcoView for Geothermal Kinetics and Pacific Energy at The Geysers.[46] A brief analysis of the geothermal process, with emphasis on its relation to the proposed project, follows:

The subterranean steam is contained in fractured rock several thousand feet below the surface. This zone of rock is overlain with strata of rock impervious to the steam and wells must penetrate these strata to reach the steam.

After land is acquired and exploration is completed, well sites must be selected. Factors such as accessibility, slope, stability, and other environmental and economic considerations enter into site selection.

The first step in drilling is the construction of an access road and pad to accommodate the drilling equipment. The size of the pad is approximately 125' x 225'. A sump is constructed nearby to contain drilling wastes. Site equipment includes the diesel drive power apparatus, generators for providing electric power of lighting and small motor driven equipment, drilling fluid ("mud") tanks, cement pump and mixer, casing and drill pipe racks, and other ancillary equipment.

The drilling operation consists of drilling with rotary bits, circulating drilling fluid to cool the bits and flush the hole, casing the hole with

steel pipe (designed to American Petroleum Institute standards and in compliance with Department of Oil and Gas Regulations,) cementing the casing in place, continuing until stream of desired characteristics is found. Particular care must be taken while cementing the casing in order to insure integrity of the well and to prevent upper level groundwater contamination.

Steam may be encountered at any time in the drilling process. Therefore, control of blow-outs (sudden increases in well pressure) is crucial to environmental protection. Non-return valves on the drill string close when sudden pressure is sensed. Blow-out preventers at the well head are operated manually and can be closed to minimize loss of steam.

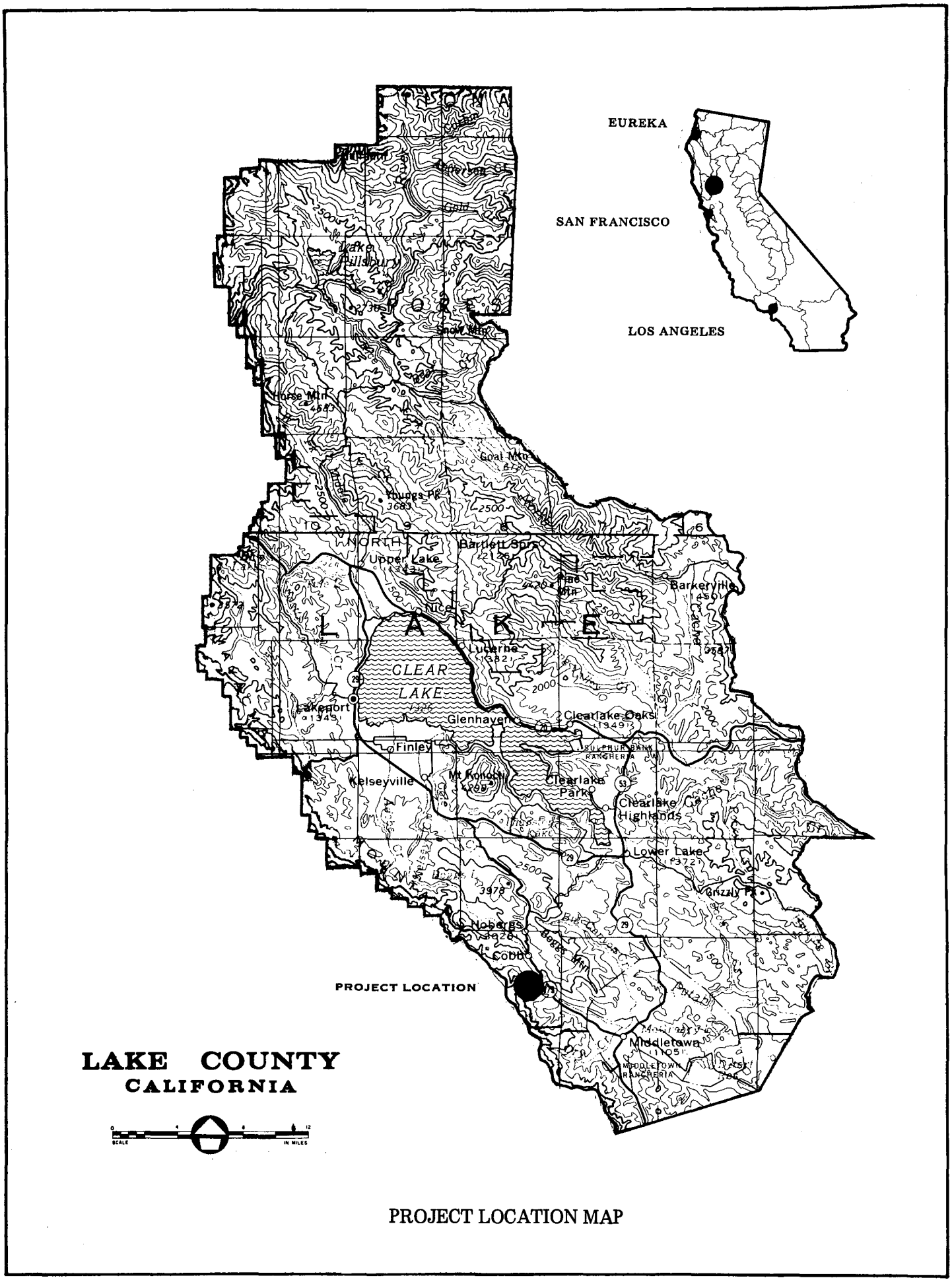
If the exploratory drilling indicates sufficient steam for production, the well is shut-in. When all wells have been completed and the power plant site fixed, steam pipelines are installed to transport the steam to the generating plant. Design of the lines is according to standard mechanical engineering practices and such factors as optimum line pressure, the acceptable friction loss between the wells and the plant, static and dynamic pressures, and thermal stresses. Insulation of the lines is mandatory for safety and structural reasons as well as minimizing energy loss through the pipeline walls.[133]

ZONING AND LAND USE CHARACTERISTICS

This region of Lake County, including the project site, is not zoned.

The Lake County General Plan shows no designation for the project site. The current adjacent land uses are geothermal developments, limited recreation (hunting, fishing, hiking), single family housing (Anderson Springs) and a school. A more detailed discussion of land use characteristics is present elsewhere in this report.

The project site is bounded to the north by Socrates Mine Road and to the east by Anderson Springs. Several geothermal projects are found in Sonoma County to the west and south.



PROJECT LOCATION MAP

FIGURE 1

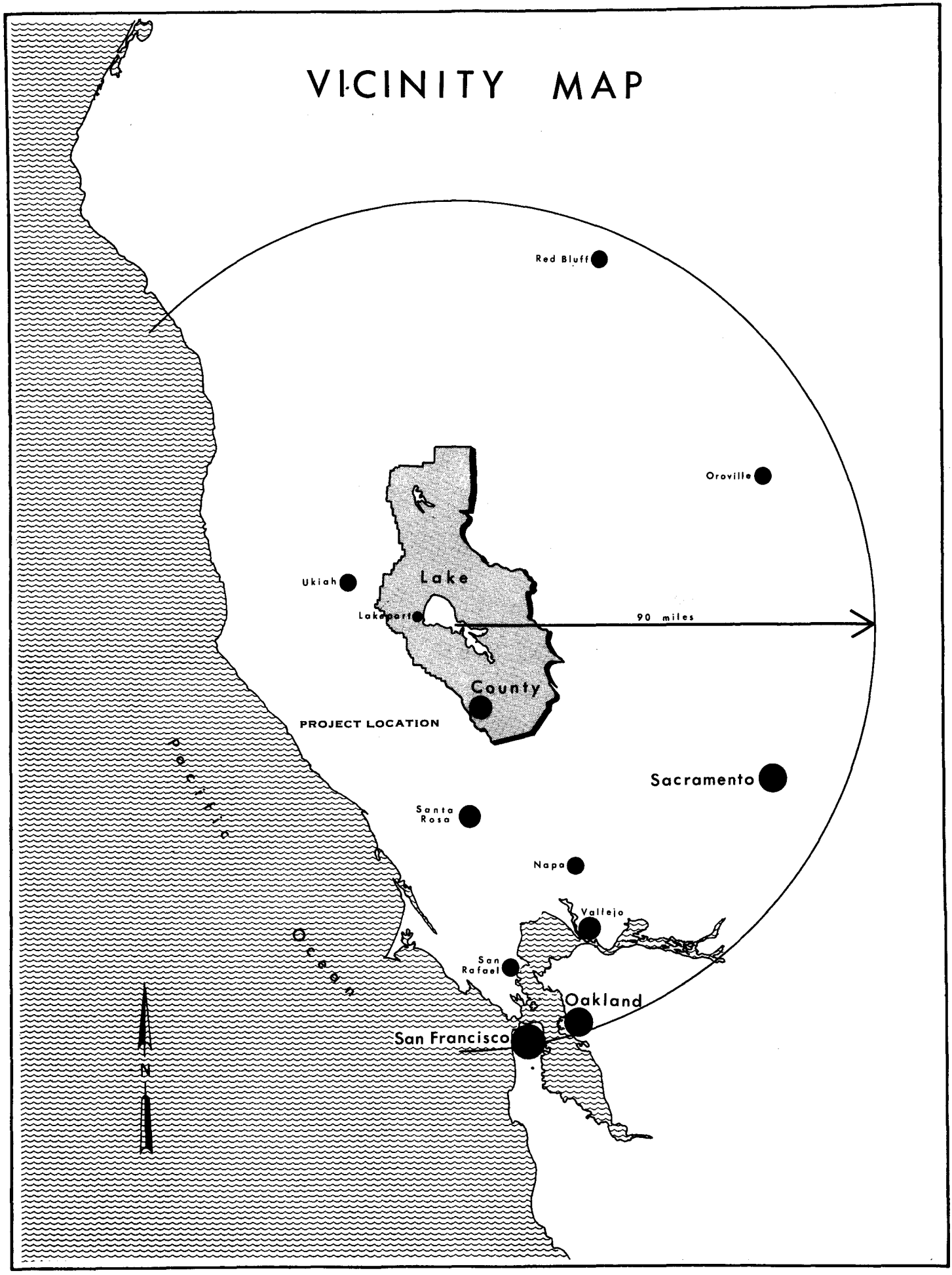
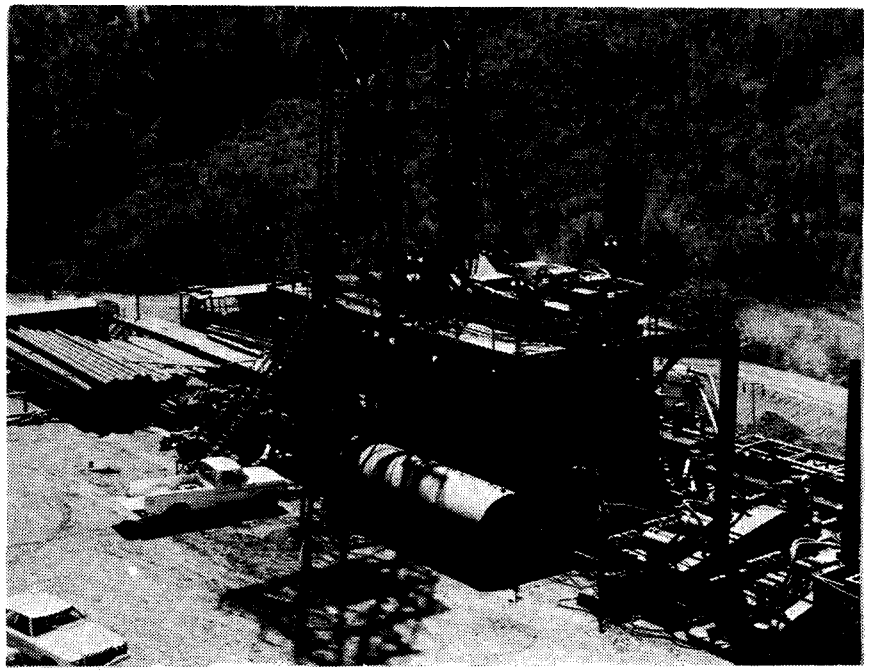
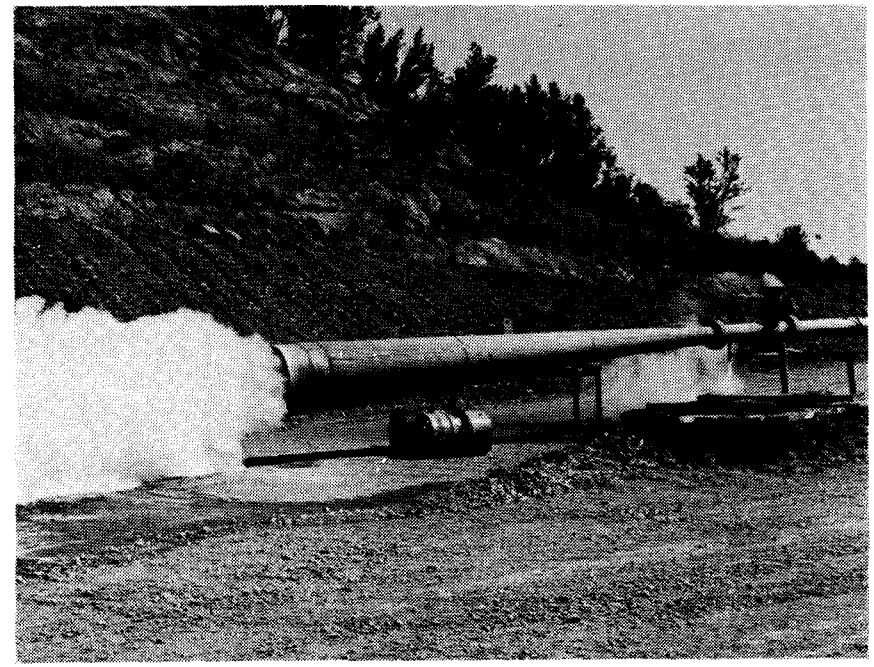

VICINITY MAP
Red Bluff
Oroville
Ukiah
Lake
Lakeport
90 miles
County
PROJECT LOCATION
Sacramento
Santa Rosa
Napa
Vallejo
San Rafael
Oakland
San Francisco
Pacific Ocean
N

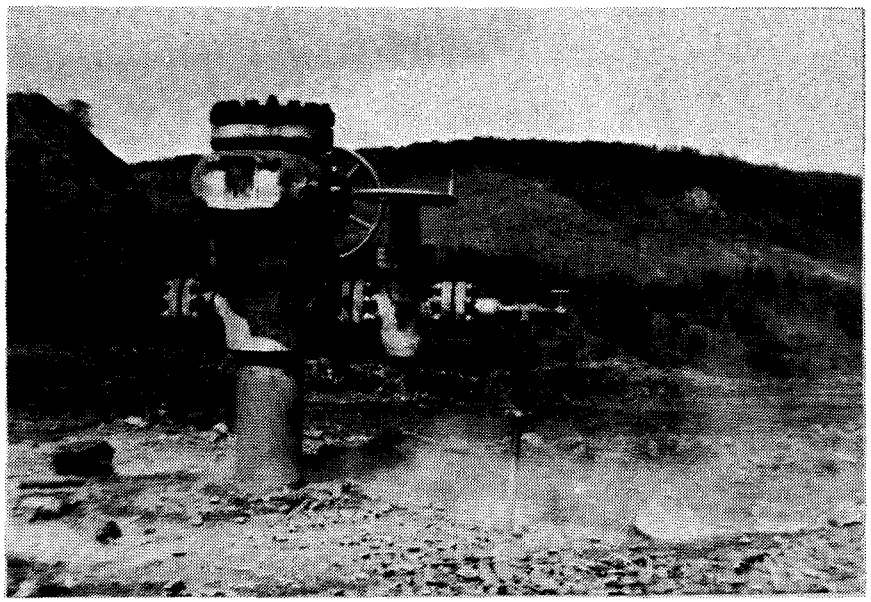
FIGURE 2



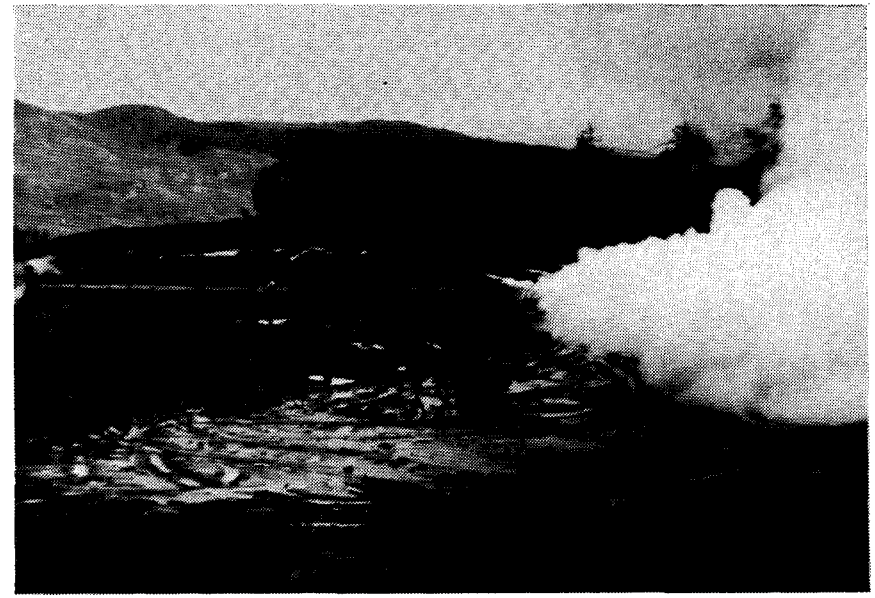
A



B

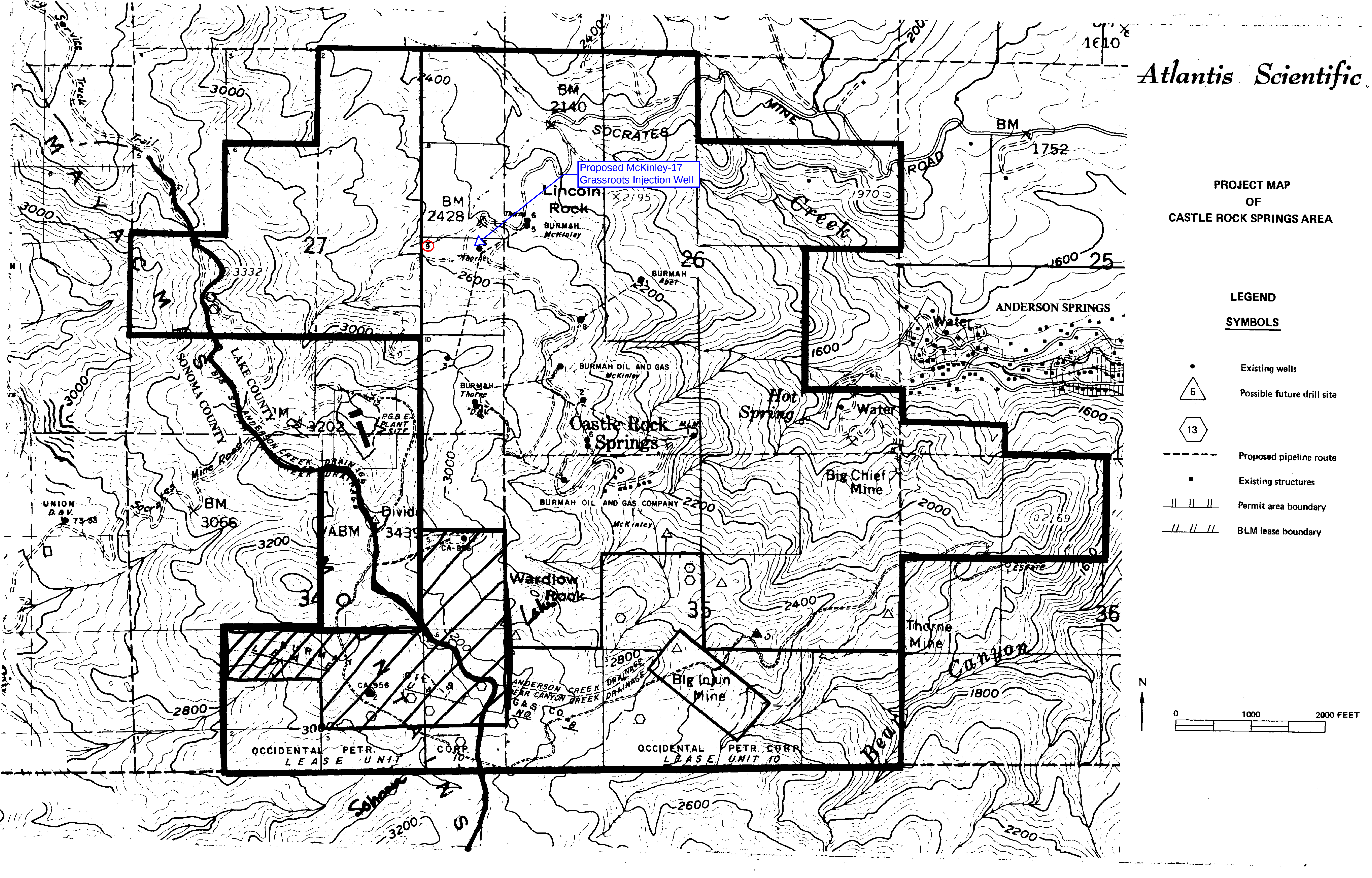


C



D

FIGURE 3



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PROJECT MAP
OF
CASTLE ROCK SPRINGS AREA
LEGEND
SYMBOLS
Existing wells
Possible future drill site
Proposed pipeline route
Existing structures
Permit area boundary
BLM lease boundary
N
0
1000
2000 FEET
Proposed McKinley-17
Grassroots Injection Well
Lincoln Rock
BURMAH McKinley
BURMAH Abel
BURMAH OIL AND GAS McKinley
BURMAH Thorne
BURMAH OIL AND GAS COMPANY McKinley
Castle Rock Springs
Hot Spring
Water
ANDERSON SPRINGS
Big Chief Mine
Wardlow Rock
Big Injun Mine
Thorne Mine
Canyon
Creek
SOCRATES
MINE
ROAD
SONOMA COUNTY
LAKE COUNTY
PG&E PLANT SITE
UNION D.B.V.
OCCIDENTAL PETR. CORP. LEASE UNIT 10
Service Truck Trail
Mine Road
BM 2140
BM 1752
BM 2428
BM 3066
27
26
25
34
35
36

GENERAL DESCRIPTION

The project site has been used in the past for limited recreational purposes including hunting, fishing, and hiking. At present, geothermal activity, including exploratory and production wells, is taking place. The topography of the site is relatively steep with high ridges and low valleys. Natural vegetation and streams are found throughout the project site. A school (Camp Verdant Vales) is located in the approximate center of the project site.

The community of Anderson Springs borders the project site on the east. The trees and topography block the view of the project site from all but a very few dwellings. Anderson Creek runs through the project site and the community.

The history of the adjacent areas and their current status are similar to those of the project site. Photographs of the site and surrounding area are presented in text, along with detailed maps of the project site.

GEOLOGY

PHYSIOGRAPHY

The site is located in the Mayacmas Mountains in the south-central portion of the Northern Coast Ranges Geomorphic Province. This province extends from San Francisco Bay to the Klamath Mountains and is bounded by the Pacific Ocean on the west and the Sacramento Valley on the east. The Coast Ranges consist primarily of northwesterly trending mountain ranges and intervening valleys. The Mayacmas Mountains, like the overall Coast Ranges, are typically broken into a series of northwest trending ridges and valleys related to the structural trend of the area.

The dominant topographic feature in the vicinity of the project site is the northwesterly trending main ridgeline of the Mayacmas Mountains which forms the boundary between Lake and Sonoma Counties. The ridgeline here ranges from 3439 feet to about 3200 feet in elevation. (see Geologic Map). Most of the Permit Area is characterized by easterly trending ridges and steep sided valleys which spur off of the main ridge. One of these easterly trending spur ridges, located between Lincoln Rock and Castle Rock Springs, roughly divides the Permit Area into northern and southern portions. Anderson Creek flows southeasterly through the northern portion of the Permit Area. The southern portion contains several easterly trending spur ridges and narrow, intervening valleys which drain toward and join Anderson Creek east of the Permit Area. The Davies Access Road near the southern boundary of the Permit Area is located on or near the crest of a major easterly trending spur ridge that forms a divide between Anderson Creek drainage to the north and Bear Canyon to the south.

The entire area is very rugged and typified by steep slopes. The main portion of the Permit Area, in Lake County, east of the main ridgeline of the Mayacmas Mountains ranges from about 3240' in the west to approximately 1510' at the eastern boundary where Anderson Creek flows through the site. Slopes of 2:1 (horizontal to vertical) or 50% are common; flatter, or less steep, slopes (except along ridgelines) are often the result of landslides. The narrow, steep sided V-shaped valleys indicate the area to be in the Youthful stage of the Geomorphic Cycle.

EARTH MATERIALS

The various earth materials present on the site can be grouped into two general categories. One group involves the soils or surficial deposits which mantle the ground surface to varying depths ranging from a few inches to several feet. For the most part, the soils are relatively recent deposits derived from the underlying bedrock through the normal processes of weathering and mass wasting. Because of their comparatively recent

origin and mode of accumulation, many of the soils tend to be rather loose, porous and unconsolidated or poorly consolidated.

In addition to the surficial earth materials commonly considered as soil or topsoil, other surficial materials present on the site include colluvium and landslide debris. Because these materials are the result of mass wasting processes, they are discussed below under the heading of MASS WASTING.

The second category consists of the various bedrock units which underlie the soils. The bedrock is considerably older and much more consolidated than the soil.

Soil

Soil types referred to in this report are based on the Vegetation-Soil Map (60A-3) prepared for Lake and Sonoma Counties by the U.S. Department of Agriculture, Forest Service.[27] The property is mantled by seven (7) different types of soil material including stony loams, stony clay loams, and loams. The Henneke stony clay loam, Josephine loam,and Los Gatos stony clay loam represent the predominant soil types present within the project site. Together, they cover approximately three-fourths of the project site. The remaining four soil types, together, comprise the remaining one-fourth of the site. Each soil type and its areal distribution is shown on the accompanying Soil Map (Figure 4). Generalized descriptions for each soil type are presented in the following paragraphs.

Dubakella Stony Loams (726) - The Dubakella series consists of well drained soils, on moderately steep to very steep slopes, which have been derived from serpentine or associated ultrabasic rocks. These soils are shallow to moderately deep, ranging in thickness from 14 to 30 inches. In a typical profile, the surface soil is a reddish brown (5YR 4/4), neutral stony clay loam about 11 inches thick. The subsoil is generally a yellowish-brown (10YR 5/4), mildly alkaline, gravelly clay. The available water holding capacity and fertility are low. Runoff is medium and permeability is moderate.[65]

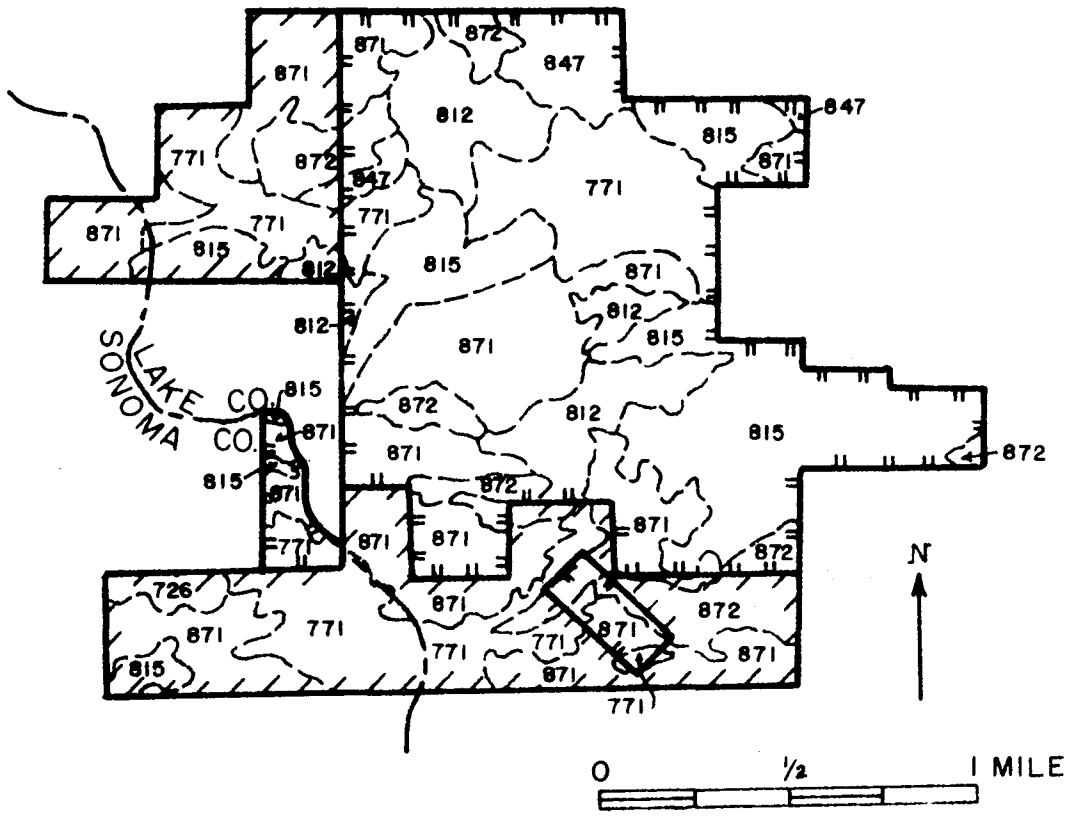
Henneke Stony Clay Loam (771) - the Henneke series consists of excessively drained gravelly loams that have a very gravelly clay subsoil. These soils commonly are derived from serpentine bedrock. Depth of soil may vary from 10 to 20 inches. In a typical profile, the surface soil (A horizon) is commonly a dusty red (2.5YR 3/2), neutral, gravelly loam about 5 inches thick. The subsoil (B horizon) commonly is a dusty red (2.5YR 3/2) to reddish brown (2.5YR 3/4), moderately alkaline, gravelly clay. Permeability is moderately slow in the subsoil. Runoff is rapid, and these soils generally have a high susceptibility to erosion. The available water capacity is 1 to 2 inches and fertility is moderate.[112]

Hugo Loams (812) - The Hugo series consists of well-drained soils derived from sandstone and shale bedrock. Depth of soil may vary from 30 to 60 inches. In a typical profile, the surface layer (A horizon) is a pale brown (10YR 6/3), neutral, very gravelly loam about 8 inches thick. The subsoil (or B horizon) is commonly pale brown (10YR 6/3), medium to strongly acid, gravelly sandy clay loam. Permeability is moderate in the subsoil of the Hugo Soil. Runoff is generally rapid to very rapid and the soil has a high to very high susceptibility to erosion. The available water capacity is 4 to 8 inches. Fertility is moderate.[112]

Josephine Loams (815) - The Josephine series consists of deep, well-drained soils, on moderately steep to very steep slopes, derived from sandstone and shale bedrock. Soil thickness may range from 24 to more than 60 inches. In a typical profile, the A horizon is a light brown (7.5YR 6/4), medium acid loam about 13 inches thick. The B horizon is commonly light reddish brown (5YR 6/4), medium acid, clay loam and, at a depth of 25 inches, is underlain by light reddish brown (5YR 6/4), medium acid, firm sandy loam. Permeability and fertility are both moderate. Runoff is generally very rapid and the soil has a very high susceptibility to erosion.[112]

Laughlin Loams (847) - the Laughlin series consists of well-drained soil derived from sandstone and shale bedrock. Soil thickness ranges from 20 to 30 inches. The surface layer (A horizon) of a typical profile is a brown (10YR 5/3), medium acid loam about 4 inches thick. The subsoil (B horizon) is generally brown (10YR 5/3), strongly acid, sandy clay loam. Permeability in the subsoil of the Laughlin soil is moderate. Runoff is very rapid and the susceptibility to erosion is very high. Fertility is considered to be moderately low. The available water capacity of this material is about 3 to 4.5 inches.[112]

Los Gatos Stony Clay Loam (871) - The Los Gatos series consists of steep to very steep, well-drained soils which are underlaid at a depth of 24 to 48 inches, by weathered shale and sandstone. In a typical profile, the surface layer is commonly a grayish brown (10YR 5/2) slightly acid loam about 7 inches thick. The subsoil may vary from a light reddish-brown (5YR 6/4), slightly acid loam to a pink (7.5YR 7/4), medium acid, gravelly clay loam. Permeability in the subsoil zone is moderately slow. Fertility is usually very low. Runoff is rapid to very rapid and the susceptibility to erosion is high to very high. Available water capacity is 4 to 8 inches.[112]



SOIL MAP OF SITE

(After Cameron and Cushman, 1952)

BOUNDARIES

BLM Lease Area

Permit Area

SOIL TYPE

726	Dubakella
771	Henneke
812	Hugo
815	Josephine
847	Laughlin
871	Los Gatos
872	Maymen

FIGURE 4

Maymen Stony Loam (872) - The Maymen series consists of shallow, somewhat excessively drained soils on steep to very steep slopes. These soils are underlaid, at a depth of 10 to 20 inches, by shale or sandstone bedrock. The surface layer (A horizon), in a typical profile, is commonly pale brown (10YR 6/3) to light yellowish brown (10YR 6/4), medium acid, gravelly sandy loam about 12 inches thick. Subsoil is generally pale brown (10YR 6/3), strongly acid, gravelly loam. Subsoil permeability is moderate and fertility is very low. Runoff is rapid and susceptibility to erosion is usually high. Available water capacity is 1 to 2 inches. [112]

Bedrock

Bedrock within the site consists of a complex and heterogeneous assemblage of rock materials including graywacke sandstone, shale, conglomerate, metamorphosed metagraywacke and ultramafic rock, greenstone, chert and serpentinite (serpentine). The bulk of this material is commonly referred to as the Franciscan Assemblage.[109]

Rock units within the site have been mapped and described by workers as early as 1903.[17] For the most part, however, the earlier rock descriptions are incomplete and mappable rock units lack specific detail. The most recent work, currently in progress, is being conducted by McLaughlin. His investigation contains greater detail than the earlier studies. Consequently, mappable geologic rock units used in this report generally follow that of McLaughlin.[110] Each bedrock type and its approximate areal distribution is depicted on the accompanying Geologic Map. A brief description of each rock type is presented below. Rock descriptions are based on the work of McLaughlin.[109 + 110]

The bedrock units within the project site can be divided into basic categories: Franciscan Assemblage and Ultramafic Rocks. Both units are comparable in geologic age ranging from Jurassic to Cretaceous (70 to 180 million years ago).

Franciscan Assemblage

Within the site, the Franciscan Assemblage can be further subdivided into two structural units (shown on Geologic Map), based on the degree of metamorphism. These units include Sedimentary and Tectonic Melange (McLaughlin's Intermediate Structural Unit) and Regionally Metamorphosed Metagraywacke (McLaughlin's Upper Structural Unit). Included within the Sedimentary and Tectonic Melange are: (a) Melange, undifferentiated; (b) graywacke, shale, and conglomerate; (c) greenstone; and (d) Blueschist grade metamorphic rocks.

(a) Melange, Undifferentiated (fsr): Located predominantly in the extreme southern portion of the Permit Area (also southern B.L.M. Lease Area), this rock unit chiefly consists of

pervasively sheared shale and gouge rock. Included within this material are tectonically emplaced blocks and resistant rock.

(b) Graywacke, Shale, and Conglomerate (fs_2): This rock unit is predominantly concentrated in the western and northwestern portions of the Permit Area (also northwestern B.L.M. Lease Area). Graywacke (sandstone), the dominant lithology is fine to medium grained and may vary from thin bedded to massive. It is relatively impervious and generally contains a high percentage of mafic volcanic detritus. Commonly associated with minor interbedded shale and conglomerate, the graywacke often possesses a slight to moderately strong metamorphic fabric.

(c) Greenstone (fg): The term greenstone refers to a fine to medium grained basic igneous rock which has undergone various degrees of metamorphism. As the name implies, the rock commonly has a greenish color. Within the site, greenstone largely represents slightly to moderately metamorphosed basaltic pillow flows, pillow breccia, tuff, and diabase which have been slightly sheared and locally extensively hydrothermally altered. Greenstone is found in the extreme southern and western portions of the site.

(d) Blueschist grade metamorphic rocks (fm): Isolated outcrops of this material are exposed sporadically throughout the site in limited quantities. This rock unit consists of foliated, phyllitic to gneissose metamorphic rocks, which contain assorted minerals (jadeitic pyroxene, lawsonite, et cetera) formed by metamorphism at high pressures. Locally, those areas indicating pre-metamorphic composition are shown by the subscript (g) for greenstone and (c) for chert.

(e) Regionally metamorphosed metagraywacke (fms): Bedrock in this category represent a highly metamorphosed equivalent of those graywacke rock units described above. Outcrops of metagraywacke are generally concentrated in the eastern and northeastern portions of the site.

Ultramafic Rocks

Several distinct ultramafic rock types occur as discrete masses within the Franciscan units. McLaughlin has defined these units as: Metamorphosed ultramafic rock and serpentinite.

Metamorphosed Ultramafic rock (mum): This material represents foliated ultramafic rocks which have been completely metamorphosed to serpentine and calcium-magneisum amphibole mineral assemblages. Exposure of this material is limited to a thin wedge located in the southern most portion of the Permit Area (also southern portion of B.L.M. Lease Area).

Serpentinite (sp): Serpentinite is an ultramafic rock consisting almost entirely of serpentine-group minerals which have been derived from the alteration of previously existing ferromagnesian silicate minerals such as pyroxene and olivine. It is generally green to greenish blue in color. Serpentinite occurs in the Franciscan Assemblage along shear zones and major fault boundaries. Within the site, serpentinite can be found in varying amounts throughout both the Permit Area and the B.L.M. Lease Area. The largest concentrations of serpentinite are located in the northcentral portion of the Permit Area and in the western and southern B.L.M. Lease Areas (see Geologic Map).

Silica Carbonate rock (sc): McLaughlin[110] has mapped a small area of silica carbonate rock in the vicinity of the Big Injun Mine. This bedrock material was formed by hydrothermal alteration of serpentinite and is commonly developed in ultramafic rocks associated with thermal springs along fault zones. In many areas, the silica carbonate rock is the host rock for mercury deposits. McLaughlin[109 + 110] estimated the hydrothermal alteration of the older serpentinite into silica carbonate rock occurred in Late Tertiary and Quaternary time.

STRUCTURAL GEOLOGY

The structural geology of the Northern California Ranges, including the Mayacmas Mountains, is dominated by northwesterly trending faults parallel or subparallel to the San Andreas Fault[84]. The geologic structure within the site, in general, conforms to the principal northwest regional trend. As indicated at the Geologic Map, the local structure is very complex with numerous variations from the main northwesterly trend. The faults separate the various bedrock units within the project site into separate tilted and folded blocks. In general, the rock units of the Franciscan Assemblage exposed within the Permit Area strike northwesterly. Owing to ancient fault movement, dips of strata occur both to the southwest and northeast with considerable range in the angle of inclination (dip) within the site. Dips are commonly moderate to steep (30° - 70°).

Faults within the site include both low angle reverse or thrust faults and steeply dipping dip and lateral slip faults. The thrust faults exposed within the site have a rather sinuous exposure or outcrop pattern with the upthrown block or plate generally to the northeast. These faults apparently represent a period of ancient faulting resulting from compressional forces in a northeast-southwest direction. The steeply dipping faults have more linear trends. These faults apparently were formed under

a different stress pattern than that which produced the thrust faults. The steeply dipping faults were probably produced by tension in a southwest-northeast direction.

The Franciscan rocks, in many instances, are separated by irregular bodies of serpentinite. The serpentinite bodies are commonly bordered by faults. In the vicinity, such serpentinite bodies occur in the north-central portion of the Permit Area and within the B.L.M. Lease Area to the south.

All of the faulting here is believed to have occurred in the Mesozoic and early Tertiary. All of the faults within the site are considered pre-Quaternary (older than two (2) million years) in age and therefore are not considered seismically active.[25]

The extensive and complex faulting within the project site has produced numerous fractures in the bedrock. Steam production is apparently from the highly fractured rock at depth. Near the ground surface, the highly fractured nature of the bedrock together with the moderate to steep native slopes have contributed to the fairly extensive landslide activity within the area.

MASS WASTING

Mass wasting refers to the downslope movement of earth materials under the influences of gravity. Mass wasting processes within the site include imperceptibly slow and intermittent downslope movement of soil and other poorly consolidated surficial deposits (creep) as well as landsliding of large bodies of earth materials.

It is probable that some soil creep occurs in most areas of the site where soil or poorly consolidated surficial materials exist on slopes. The amount of movement involved is very minimal, commonly only a small fraction of an inch per year.

Of considerably greater importance are the extensive landslide deposits present within the site and vicinity. Because of the highly fractured and sheared nature of the rocks of the Franciscan Assemblage, these materials are prone to landsliding. Landslides within the site can be separated into three general categories. Two of the categories involve unconsolidated to poorly consolidated colluvium. The colluvium typically consists of angular blocks of bedrock ranging from one to several inches in maximum diameter in a matrix of silt and sand. In many areas, on relatively steep slopes, this material has accumulated in thicknesses up to a few tens of feet. These accumulations are typically in the swales. The colluvium is inherently unstable and prone to rotational slump and debris-earth slide-flow type slope failures.[40] Most of the rather elongate landslides in swales are of the debris-earth slide-flow type (see Geologic Map). In these landslides, it is common that different parts of the landslide body move independently and numerous smaller slump blocks can be found within

the larger landslides. The head of most landslides, especially the heads of slump blocks, are typically expressed topographically as nearly level terraces below a steeper cliff or scarp. These terraces may pond water during the winter and spring and produce anomalous marshy areas surrounded by steep slopes. As ground water is a major contributor to slope instability, this tends to accelerate or contribute to renewed movement of the landslide. Most of the landslides involving colluvium are currently active or have been active recently. The rate of movement of these active slides may range from a few inches to a few feet per year. Most movement generally occurs during the winter and spring when the weight of the landslide mass is increased by infiltration of water following rains.

As the topography of the area is very rugged with steep slopes, nearly level areas large enough for drill pads are uncommon. Because of this, the nearly level terrace areas, common at the head of landslides or slump blocks within larger landslides, were utilized for well sites prior to the period when any geologic or soil engineering data were considered in well siting. Two such areas within active landslides involve McKinley Wells 2 and 6.

In addition to the landslides primarily involving near surface earth materials (colluvium), landslides involving large blocks of bedrock are present on the site. These larger bedrock landslides, in some cases, such as the large landslide in the central portion of the Permit Area directly east of Pacific Gas and Electric Plant Site, appear to be very old and exhibit no indication of present or recent activity. However, these bedrock landslides typically consist of higly fractured earth materials, and as such, are prone to shallower slump or debris flow type movements.

A large portion of the slopes within the site are basically unstable owing to the steep slopes, high rainfall, unconsolidated or poorly consolidated surficial earth materials (soil and colluvium) and weak, highly fractured and sheared bedrock. As such, many landslides have occurred within the site, most prior to man's involvement and exploitation of the region. There are also areas which, although the slopes have not yet failed, are only very marginally stable and could, at some time in the future, fail naturally.

Modification of the topography by man (grading) in this area has been primarily related to road construction for access to mines and for logging purposes with additional roads and well sites constructed more recently in relation to exploration and exploitation of the geothermal resources. Most of the grading within the area was done without enough consideration of the numerous existing landslides, inherently unstable slopes, or engineering properties of the earth materials. The grading typically involved removal of vegetation, cutting of oversteep, unstable slopes and dumping of uncompacted or poorly compacted and thus unstable fills. This type of grading also increases infiltration of water which decreases the strength of the earth materials and contributes to slope instability and failure. Thus, areas so graded are often unstable and subject to failure. Many of the roads within the area are subject to continued

maintenance. In addition, well sites such as McKinley 2 and 6 have been subject to slope failure.

It should be noted that it is possible to grade and locate structures and other facilities in the area safely. This can only be accomplished, however, if careful consideration is given to all geologic factors involved at each individual site and if all grading and construction is done in compliance with good engineering practices.

EROSION

Erosion is the natural process or group of processes by which earth materials at the surface of the earth are loosened, dissolved, or worn away and simultaneously removed from one place to another. The primary agent of erosion within the site is running water. While most of the bedrock materials within the site are relatively resistant to erosion, surficial earth materials including soil, colluvium and landslide debris are, in general, moderately to highly susceptible to erosion. The natural vegetation cover tends to retard erosion. Thus, where the vegetation has been removed, erosion is accelerated. Erosion can also be accelerated where running water is concentrated into channels and the volume and/or velocity of flow is increased.

Within the site higher than "natural" erosion rates have occurred in the past where vegetation has been removed and grading was done without proper drainage controls. Some attempts to retard the rates of erosion in such areas, including revegetating the area and construction of berms to prevent runoff over graded slopes has helped considerably. However, erosion rates in most graded areas within the property are still somewhat higher than those prior to grading.

SUBSIDENCE

Subsidence has been known to occur in other areas where petroleum and associated brine water, as well as fresh ground water, have been withdrawn.[3 + 106] Exploitation of a hot-water geothermal field in New Zealand has also resulted in subsidence[78]. In general, where such subsidence has been recorded, it has apparently resulted from the withdrawal of liquid contained as interstitial liquid in relatively poorly consolidated sediments or clastic materials.

The geothermal resource within the Castle Rock Springs area is dry steam rather than a liquid. Further, the steam is contained in fractures in hard, very well consolidated, lithified and locally metamorphosed graywacke sandstone and possibly in fractures in the associated hard, dense, igneous rock. No subsidence related to geothermal exploitation in this area is known to have occurred and none is anticipated. This conclusion is substantiated by the earlier geothermal development which has taken place in The Geysers area west of the site. No subsidence is known to have occurred in The Larderello, Italy dry steam geothermal field which

has been in production over 60 years.

The reservoir of a typical dry-steam geothermal field is normally characterized by solution channels, fracture zones or other permeable cavaties which contain vapor, possibly from the "boil off" of a deeper hot water reservoir. Dry-steam geothermal fields are unique in that the pressure of the vapor is generally near-constant throughout the vertical section of the reservoir.[14] According to Bowen[14] steam temperatures and pressures for The Geysers area (as well as for most drysteam fields so far discovered in the world) are about 465°F and 480 psia. This near constancy of pressure even at the depth greater than 8,200 ft. suggests that for a dry-steam field to exist the host rock must be competent and therefore not subject to subsidence from the removal of vapor.[14]

It should be noted that without precise survey level lines over long distances for many years, it would be essentially impossible to determine if subsidence were occurring within the area. The U.S. Geological Survey performed the first precise leveling of the general area in the summer of 1973. It will be several years, however, before resurveying will indicate if any subsidence is occurring (B.E. Lofgren, personal communication).

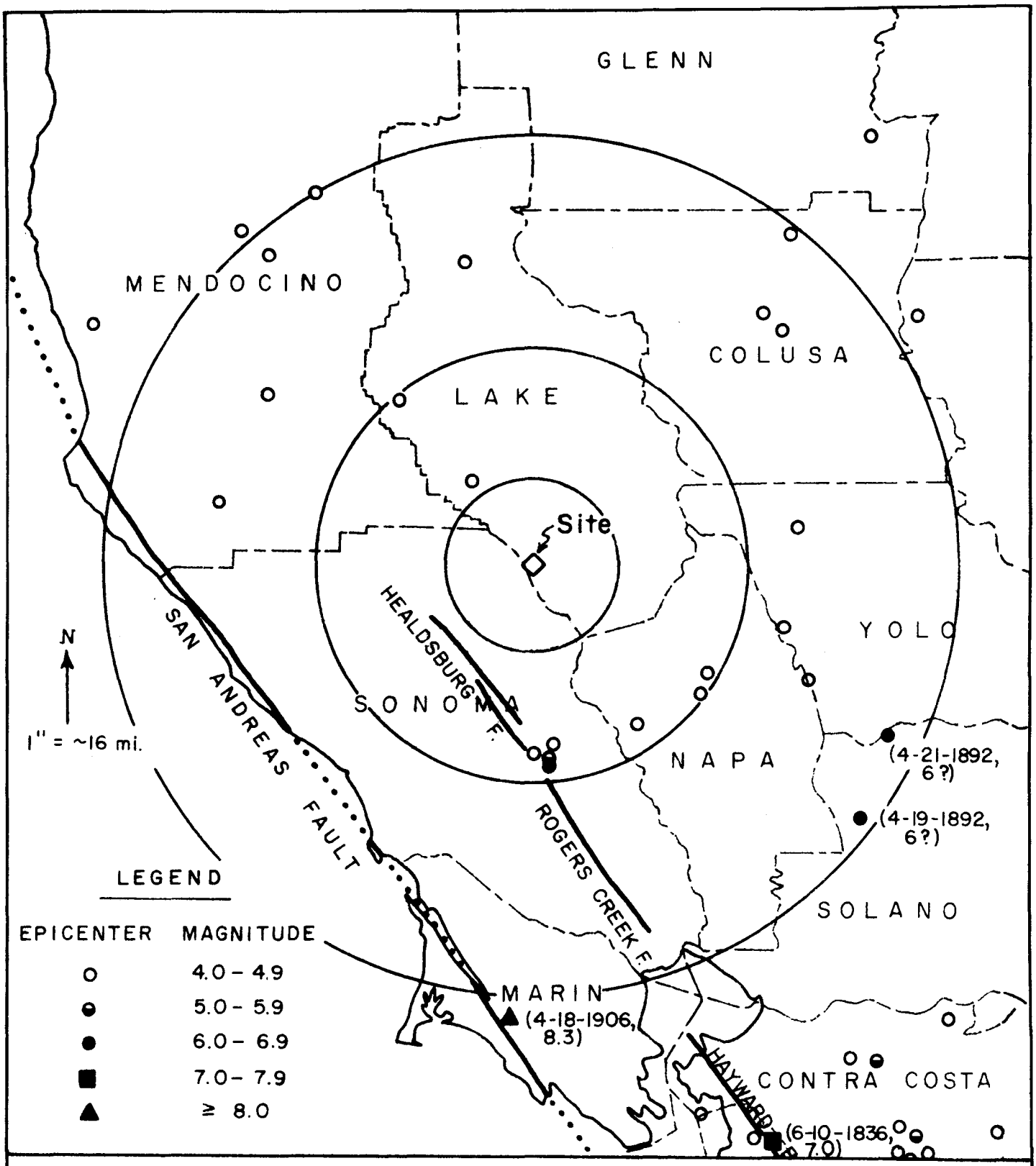
SEISMICITY

Regional Active Faults

The Coast Ranges of California are dominated by northwesterly trending faults. The San Andreas Fault is the primary fault within the group which also includes the Hayward and Calaveras Faults south of San Francisco Bay and the Healdsburg and Rogers Creek Faults near Santa Rosa (see Figure 5, Map of Earthquake Epicenters). With respect to the site, the most important known active faults are the San Andreas and the Healdsburg Faults.

The San Andreas Fault is located some 34 miles southwest of the site. It is one of the major structural elements of California extending from north of Point Delgada southeasterly to the Gulf of California[25]. It is seismically active and movement on the San Andreas Fault produced the 1906 "San Francisco Earthquake". With a magnitude of 8-1/4, this is the largest earthquake known to have occurred in California.

The Healdsburg Fault located 12 miles southwest of the property is the nearest known active fault to the site. Although no historic ground surface rupture is known to have occurred on the Healdsburg Fault, movement on the southern end of the fault apparently caused the 1969 Santa Rosa Earthquake.[25 + 139]



EARTHQUAKE EPICENTERS 1934 - 1971
(pre 1934 assumed locations and magnitudes are noted)

After CDMG, 1972

Circles represent distances of 10, 25, and 50 miles from the site

FIGURE 5

Local Faults

Although there are numerous faults within the site (see section on STRUCTURAL GEOLOGY and Geologic Map), none of these faults are known to be seismically active. Further, none are known to have experienced any ground surface rupture within historic time.[25]

Earthquake History

Figure 3 is a map of known earthquake epicenters of magnitude 4.0 and above from 1934 through 1971. Figure 3 is based primarily on California Division of Mines and Geology data (1972 and 1973). This information was checked for accuracy and appropriate modifications and additions were based on California Department of Water Resources, 1964; Coffman and von Hake, 1973; Clark and Hauge, 1971; and University of California, Berkeley, 1973.

The earliest known earthquake which may have had any significant effect at the site occurred at 4:10 PM (PST) on July 31, 1885. This earthquake reportedly produced a Modified Mercalli Intensity of VII at Cloverdale, some 15 miles west of the site.[70 + 132] Other significant earthquakes to affect the site include the magnitude 8-1/4 San Francisco Earthquake of 1906. This earthquake was centered approximately 50 miles south of the property on the San Andreas Fault and was reported to have produced Modified Mercalli Intensity of VI to VII within the site.[101] The Santa Rosa Earthquakes of October 1, 1969 which were centered about 20 miles south of the site, had magnitudes of 5.6 and 5.7 and produced Modified Mercalli Intensity of V at Middletown near the site.[139] The nearest earthquake of magnitude 4.0 or above known to have occurred near the site occurred on May 7, 1955, and had magnitudes of 4.6 and 4.2. They were centered approximately 12 miles northerly of the property and had no significant effect within the site.[26 + 32].

Microearthquakes

During a three week period in 1971, Hamilton and Muffler[74] made a study of microearthquakes at The Geysers west of the subject site. They found a grouping of microearthquakes with epicenters in a zone about 4 km long and 1 km wide passing through The Geysers geothermal field along a principal fault zone. The events were all very small with magnitudes mostly less than 0 (zero). These microearthquakes were very shallow with focal depths ranging from near the surface down to about 4 km. All epicenters recorded during the Hamilton and Muffler study were more than one (1) mile westerly of the subject parcels. A composite fault-plane solution indicated right-lateral strike-slip faulting on a NNW-striking plane subparallel with the regional fault pattern. The fault-plane solutions determined for the main epicentral zone do not correlate well with the local geologic structure. The strike-slip movement indicated by the seismic data is in contrast to the predominant dip-slip movements suggested by geologic relations.

The right-lateral strike-slip movements are, however, consistent with the regional deformation associated with the San Andreas Fault System. [74]

The study by Hamilton and Muffler did not reveal if the concentration of microearthquakes in the producing part of The Geysers steam field is natural or is somehow caused by the extraction of steam. They noted, however, that microearthquakes are common in undeveloped geothermal areas and that steam production did not affect the occurrence of microearthquakes in other parts of the world.

Seismic Potential

Based on currently available data the most likely faults to produce potentially damaging earthquake shaking and associated effects at the site are the Healdsburg Fault and San Andreas Faults. The California Division of Mines and Geology[66] has estimated the Maximum Expected Earthquake magnitudes for these faults to be 6-3/4 and 8-1/4, respectively. If these events were to occur at the nearest point on the faults to the site, a 6-3/4 magnitude earthquake on the Healdsburg Fault could produce a Maximum Credible (Peak) Bedrock Acceleration of about 0.30g (gravity) with strong ground shaking (greater than or equal to 0.05g) lasting approximately 20 seconds.[12 + 130] The Repeatable High Ground Acceleration from such an earthquake would probably be on the order of 0.2g. The level of Repeatable High Accelerations is generally more important than maximum or peak acceleration with regard to structural design.[125] A magnitude 8-1/4 earthquake on the San Andreas Fault at the nearest point to the property could produce a Maximum Credible (Peak) Acceleration and Repeatable High Ground Acceleration of about 0.23g with strong ground shaking lasting about 28 seconds.[12, 125 + 130]

While such possible strong ground shaking is significant, it should be noted that the Maximum Credible Acceleration for the site is considerably lower than Maximum Credible Accelerations for most of the more heavily populated areas of coastal California. Structures, as well as cut and fill slopes, can be designed and built which can resist the maximum anticipated ground motion with little or no damage.

The maximum strong shaking which can be anticipated at the site could accelerate movement of active landslides, reactivate old landslides which are presently inactive and trigger new landslides. Seismic consolidation or settlement, differential compaction and lurching of thick unconsolidated colluvium and landslide debris within the site could also occur. As none of the faults within the site are known to be seismically active, ground surface fault rupture within the property appears to be unlikely. The nature of the earth materials within the site and the distance from significant water bodies indicates that damage during an earthquake from liquefaction, tsunami, seiches or flooding (failure of dams or levees) within the property does not appear a possibility.

MINERAL RESOURCES

The area encompassing the site is well known for its association with quicksilver (mercury) deposits. Three mines exist in or near the southern and southeastern portions of the site. These mines include: the Big Chief, Big Injun, and Thorne. Approximate location of each mine is shown on the Geologic Map.

Ore deposits found in the mines are apparently all in the Franciscan rocks, although a silica-carbonate rock ledge was prospected at the Big Injun Mine. The ore is characterized by the presence of considerable native mercury as well as cinnabar (mercury mineral). Cinnabar generally occurs as grains disseminated in the altered sandstone and in small breccia zones. Observed ore shoots have also been associated with fault and breccia zones.[173]

Hydrothermal activity has persisted for a long time in the vicinity of the mines. Consequently, the mine waters of both the Big Chief and Big Injun Mines are warm and have a strong odor of hydrogen sulfide. [173]

Mercury production in the mines reached its peak during the earlier years (turn of the century) of mine development.[173] Production in later years has been minor, except for a brief flurry of activity which occurred during a period of high mercury prices in the middle and late 1960s. The mines are now essentially inactive owing to a depressed mercury market.

Atlantis Scientific

GEOLOGIC MAP OF CASTLE ROCK SPRINGS AREA

LEGEND

STRATIGRAPHY

- Qal — Alluvium
- sc — Silica carbonate rock

Franciscan Assemblage

- fsr — Sedimentary-Tectonic Melange, undifferentiated
- fs_2 — Graywacke, shale, minor conglomerate
- fg — Greenstone
- fm — Blueschist rocks
  - fmc — chert
  - fmg — greenstone
- fms — Regionally metamorphosed metagraywacke

Ultramafic rocks

- sp — Serpentinite
- mum — Metamorphosed ultramafic rock

SYMBOLS

- 33 — Strike and dip of bedding
- Contact, approximately located
- Fault, approximately located, dotted where concealed
- Thrust fault, approximately located, dotted where concealed, barbs on upper plate
- Scarp line – may be either fault or landslide related, barbs on downslope side
- Landslide, arrow indicate direction of movement
- Permit Area boundary
- B.L.M. lease boundary

(After McLaughlin (1975), modified from unpublished field mapping of W.T. Box, (1975) of Burmah Oil Co.)

- Possible future drill site
- 19

N

0 1000 2000 FEET

HYDROLOGY AND WATER SUPPLY

The project site is drained by a network of small streams. The main stream is Anderson Creek flowing southeasterly into Putah Creek. Anderson Creek has two main tributaries, Gunning Creek (north fork) and Bear Canyon Creek (south fork), all receiving runoff from small unnamed tributaries.

The main drainage is Putah Creek, flowing southeasterly into Lake Berryessa, Napa County, thence to the Sacramento River. The closest gauging station is on Putah Creek near Guenoc[159] recorded temporarily from 1904-1906, then continuously from 1930, financed by the U.S. Geological Survey, Water Resource Division (runoff from one-hundred twelve (112) square miles). Average recorded monthly flows are in Table 1.

Steep terrain dominates, with Anderson Creek's slope approximately ten (10) percent and unnamed SW tributaries approximately twenty (20) percent. Steep slopes and low substrata permeability cause rapid runoffs, with limited infiltration or percolation to ground water basins. Therefore, ground water contributes small amounts of runoff, significant during late spring and early summer. Near surface ground water, not related to the steam field, is fairly common within the area. This can be ascertained by the presence of numerous cold springs and seeps within the area. These springs and seeps are particularly common in landslides. This ground water is primarily in the poorly consolidated, surficial colluvium and landslide deposits and within fractures in the bedrock. The volume of near surface ground water within the site is not believed sufficient to yield significant amounts of water for residential or industrial uses.

Most precipitation and ninety-three (93) percent runoff occurs from December to April, with little or no runoff from snow storage. Some small streams are ephemeral due to insufficient ground water flow for year-round existence, but all major creeks are not affected in permanent flows.

Area runoffs are characterized as storm events, with minimal interception or retention storage. Hydrograph curves rise steeply initially, peak sharply, with gradually falling slopes to base-flow levels.

The study area covers less than two (2) square miles, which is less than two (2) percent of the area upstream from the recording gauge. Therefore, precise calculations on runoff quantity are impossible.

The project site drains approximately 1.88 square miles, with estimated average annual runoff at 3.4 cubic feet per second (cfs). Table 2 lists estimated average annual areal runoff.

TABLE 1

AVERAGE MONTHLY AND ANNUAL STREAMFLOW OF PUTAH CREEK NEAR GUENOC

	cubic fee per second (cfs)
January	54.1
February	52.6
March	35.5
April	19.1
May	6.1
June	0.9
July	0.7
August	0.4
September	0.3
October	1.5
November	5.8
December	34.3
TOTAL	211.3

The average annual flow for 37 years is 203 cfs. The maximum discharge of 32,000 cfs occurred on December 11, 1937.

TABLE 2

ESTIMATED MONTHLY AND ANNUAL RUNOFF FROM THE PROJECT SITE

	Cubic feet per second (cfs)
January	0.74
February	0.88
March	0.72
April	0.44
May	0.22
June	0.12
July	0.06
August	0.04
September	0.02
October	0
November	0
December	0.20
TOTAL	3.44

Averages estimated using Thornwaite (1957) water balance method.

Annual precipitation in the study area is quite high (from forty eight (48) to one hundred and thirty five (135) inches.) This precipitation occurs mainly from October through March. Table 3 lists precipitation at Anderson Springs, California, from July 1962 to June 1973.[11]

The project site serves as part of the surface water supply source for the population of Anderson Springs. The water supply system is managed by the Anderson Springs Water Company, which consists entirely of surface water sources. That is, there currently are no groundwater wells in the system. The water is gathered via the following system:

1. A two (2) inch water line from Hansen Creek, which is a tributary of Bear Canyon Creek

2. Three one (1) inch water lines from three springs in the area

3. A three (3) inch and a one and one-half (1-1/2) inch water line from Gunning Creek.

Water is collected by stream side diversions to screened barrels thence to hillside piping. From these sources the water flows to eight (8) storage tanks which have a total capacity of seventy thousand (70,000) gallons. A total of one hundred and sixty-two (162) residents are served from this system. Each resident is currently charged forty eight dollars ($48) per year with no limit on the amount of water used.

The Anderson Creek Water Company has water rights for a total of eighty (80) gallons per minute (gpm). All of the surface water in the area is currently allocated to various users.

The system is operated so that water is only collected from the creeks and springs during periods of clear weather. As soon as it starts to rain, the pipe lines are shut off at the tanks in order to keep sediment out of the supply.

There currently is no filtration of the water. Chlorination is applied directly into the water tanks. This Anderson Creek water system is currently under review by the Lake County Health Department. It is anticipated that several major changes may be required including water filtration.

TABLE 3

Anderson Springs, California

Precipitation, inches

Water Year 19--	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	TOTAL
72-73	0	0	1.70	7.45	13.63	12.31	29.10	23.22	6.14	0	0	0	93.55
71-72	0	0	0.95	0.70	8.17	18.09	5.96	11.64	2.60	8.64	0.55	0	57.30
70-71	0	0	0	5.80	22.54	32.00	11.04	-	16.72	-	-	-	88.10
69-70	0	0	0	5.05	2.22	44.95	66.48	8.95	6.30	0.40	0.55	0	134.90
68-69	0	0.30	4.05	7.45	5.08	22.61	45.95	28.66	3.52	5.65	0	0	123.27
67-68	0	0.35	0.20	3.90	8.80	14.65	30.21	13.59	9.35	1.00	1.18	0	83.23
66-67	0	0	1.70	-	27.13	21.71	36.15	0.60	19.36	15.87	0.70	7.00	130.22
65-66	0	0	0	0	22.51	19.80	26.58	8.98	2.17	3.65	0	0	83.69
64-65	0	0	0.26	6.40	11.27	39.84	21.92	2.47	3.55	11.08	0	0	96.79
63-64	0	0	0	7.50	17.12	1.75	11.97	1.65	4.92	0.40	2.95	0	48.26
62-63	0	0	0.75	22.85	4.65	11.17	19.90	7.35	1.60	22.95	2.14	0	93.36

January 1973: 14" snow

WATER QUALITY AND AQUATIC BIOLOGY

The project site is characterized by the presence of mixed evergreen forest in moister localities with either oak woodland or chaparral in the drier areas. Ridges and exposed southern slopes generally consist of the chaparral vegetation. Bottoms of ravines, areas around streams, and other low protected areas are generally mixed evergreen consisting of douglas fir, madrone, maple, bay and others. A variety of oaks tend to be the dominant vegetation type in areas intermediate to the two above. Side slopes in this region tend to be very steep, commonly fifty percent or greater, and the areas soils are erosive types; these two factors combine to create potentially high erosion rates. The drainage system in the project site consists basically of the Anderson, Gunning and Bear Creek drainages which join and then empty into Upper Putah Creek. Flow regimes for these streams are not specifically known. Streams in this general area, though, tend to have high and very rapid runoffs in the rainy season and low flows during the dry summer months. Both Anderson and Bear Creeks are permanent streams, as are many of their tributaries. Gunning Creek, however, approaches low flows of less than two (2) cubic feet per second (cfs) in late summer (personal communication with Mr. Hazen Dennis.) Because the streams exhibit continuous flows, they offer permanent habitat to many terrestrial and aquatic organisms.

During June of 1975, preliminary water quality analysis and examination of the stream biota within these drainages was performed in order to estimate present water quality and the condition of the existing ecosystems. Six (6) sites, chosen to give meaningful data both initially and later, if monitoring should prove necessary, were sampled. Descriptions of sampling locations and a summary of physical water quality are given in Table 4. In general, the water in these streams is of high overall quality. All measurements made were substantially better than drinking water minimum standards. With two exceptions, no abnormal states were observed. Hot Springs Creek was more turbid than the others and showed high suflide (SO_4) levels. This seems to be an historical occurrence due to the physical nature of hot springs in the area. Coliform counts, taken in 1974, showed abnormally high counts in Anderson Creek during summer low flows. It is believed that this was a result of poorly located and overstressed septic tank systems in the Anderson Springs area.

Examinations of the stream biota at these sites were also indicative of high water quality. All stations showed a diverse invertebrate fauna with most species common to all sampled sites. Differences, occurring mainly in the less common species, are most likely due to inherent sampling inefficiencies and differential occurrence of special habitats (protruding root masses, slick or very smooth rocks, areas of detritus and sediment accumulation, etc.) Trout and sculpins were also found at most sites. Salamanders and frogs were also found. These vertebrates seemed generally abundant, although they were not specifically sampled for.

TABLE 4

WATER QUALITY DATA AND SAMPLING SITES

STATION	TIME(PM)	TEMP(C)	EST. FLOW (CFS)	SUBSTRATE*	TURBIDITY (FTU)	pH	$SO_4^=$ (ppm)	Cl^- (ppm)	TOTAL HARDNESS(ppm)
1	5:30	18	4-5	B,C	6	7.5	1	5	48
2	6:00	20	1-2	C,Br	15	7.0	92	5	145
3	4:30	19.5	1	G,C,S,Sd	6	8.0	6	5	125
4	3:30	20	10	B,C,G,S	9	7.8	8	5	70
5	3:00	19.5	15	B,C,G,S	8	7.5	5	5	85
6	2:30	18.5	5-7	B,C,G,S	8	7.9	1	5	95

*KEY:

B - boulders
C - cobble
Br- bedrock
G - gravels
S - sands
Sd- fine sediments

SAMPLING STATIONS

1. Upper Anderson Creek at bridge on upper-most Anderson Springs Road
2. Hot Springs Creek, 300 yds. above junction of two roads
3. Bear Creek, 150 yds. above confluence with Anderson Creek
4. Anderson Creek, 200 ft. above confluence with Putah Creek
5. Putah Creek, 200 ft. below confluence with Anderson Creek
6. Putah Creek, ½ mile above confluence with Anderson Creek

Appendix J lists organisms found. All measurements made indicate that the aquatic ecosystems in the Castle Rock area are presently in excellent condition. Cool temperatures and low concentrations of dissolved and suspended materials support a diverse insect fauna which in turn supports a desirable vertebrate population, including, in particular, trout which come from Lake Berryessa to spawn and bullfrogs.

Streamside vegetation results from permanent flows along the lower reaches of the larger creeks and protects the habitat from excessive temperatures during summer flows. The present high water quality must be maintained, however, if present consumptive uses, recreation, and aesthetic values are to be maintained. Summer temperatures are high in this area and summer flows low, so even relatively minor impacts which disrupt any segment of the existing cool water biota will substantially degrade these systems. There is no evidence that present uses and impacts are substantially degrading aquatic habitats.

The presence of high water quality in the future in this area is important for a number of reasons. These reasons are as follows:

- The residents of Anderson Springs are directly dependent on these streams for their daily usage, including drinking water. Consumers of the waters of Lake Berryessa are also affected, in that these waters eventually end up there via Putah Creek.

- Trout populations, presently high, are dependent on the continuance of cool, clear, non-toxic waters.

- Contact water sports also rely on continuing water quality. Anderson Springs residents have formed swimming areas by constructing small dams on Anderson Creek. Lake Berryessa offers swimming, boating, and fishing.

- Scenic amenities for the Anderson Springs residents, as well as for visitors, depend on maintaining water quality. Many residences have streamside lots and most areas relating to human relaxation are near streams.

AIR QUALITY

The climatology for Northern California with emphasis on The Sonoma-Lake County area has been discussed in detail in previous EIRs for geothermal wells.[42, 49, 50, 150] Thus, a summary of the climatology will be given here, in reference to environmental impact on air quality.

The average area climate has warm summers and mild winters, because of two seasonally persistent circulation features called the Pacific High and Gulf of Alaska Low. The winter is alternately dry (but not necessarily fair) and stormy. Storms are not of great interest as to air pollution, thus minimal discussion is given. The winter dry periods, however, are of interest. The summer climate is dominated by a large anti-cyclone which promotes weak downward vertical atmospheric movements, the sole source of subsidence inversion over California during the warm summer seasons.

Winter dry weather in one instance caused strong high pressure areas simultaneously developing a weak surface trough over the West Coast resulting in strong north to northeast flow over the Mayacmas Mountains. These are similar to the Santa Ana winds of Southern California, and are extremely dry. Wind speeds may gust up to sixty (60) mph over various ridge lines. Another phenomenon resulting from weak high pressure over the southern Pacific Coast together with little or no cloudiness aloft and low relative humidity causes radial cooling of the earth surface at night. When surface layers are cooled to the dew point, dense ground fog occurs. A significant feature of this weather condition is a ground-based radiation inversion which traps pollutants near the ground causing high pollution potential. Radiation inversion is especially prevalent in valley regions similar to that existing in the vicinity of the permit site. During such conditions "drainage winds" invariably develop, which drain downslopes through the project area, and can carry pollutants into the Anderson Springs region.

The summer climate, dominated by a subsidence inversion, traps the marine layer and the pollutants entering that layer. The top of the mixed layer--or marine layer--is generally found at an average elevation of two thousand (2,000) feet. Below the mixed layer, surface wind characteristics are determined by the pressure gradient between an off-shore high and an interior thermal low; and above the layer wind characteristics are related to the subsiding circulation associated with the anti-cyclone aloft. The Mayacmas Mountains are above the mean level of the mixed layer, and thus those characteristics of the marine layer are undoubtedly absent in the region. Consequently, greater circulation could occur locally during the day, to disperse pollutants in the area. However, at night circulation is reduced and the development of locally induced downslope drainage winds may again promote increased concentration of pollutants in Anderson Springs and other lower valley regions.

An interesting feature of the flow of the marine air from the San Francisco Bay area into the Sacramento Valley was demonstrated by Schultz, et al.[42] This study indicated that, during summer, polluted air from the Bay region is transported into the Sacramento Valley with a circulation region often developing on the eastern slope of the Mayacmas. Thus, there exists a typical circulation pattern which can potentially concentrate emissions from The Geysers into the atmosphere in the Sacramento Valley. Since this atmosphere contains pollutants (i.e., high oxidant levels) from the Bay area, a condition for increased conversion of hydrogen sulfide (H_2S) to sulfur dioxide (SO_2) and sulfates may exist. (Further discussion is in the impact section.) The results of the above study indicate that there is a very slow movement of air during the morning hours and that the entire mass then moves northward to be concentrated in the upper Sacramento Valley.

Precipitation data for the general area of Anderson Springs appear in the Bureau of Land Management (BLM) report[150] showing the majority of the rainfall in the winter months, October to April. For the period 1962-72, the average yearly rainfall was 94 inches. It is interesting to note the strong relationship of precipitation to location, e.g., at Middletown, a few miles east of Anderson Springs, annual average precipitation for a comparable period was 46 inches.

The above-mentioned BLM report does not include any temperature data for Middletown or Anderson Springs. However, temperature data for Lakeport and Angwin-Pacific Union College show average summer temperatures in mid-to-low seventies (70s). Derivations in a previous EIR[49] show the average temperatures in the Anderson Springs area to be slightly lower, but with maxima in the upper nineties.

In brief, there are two significant features of climatology in the project site. First, because of the local meteorology and topography, there will probably be periods of "drainage winds" down the slope through the project site and into Anderson Springs. During the winter, this situation may be aggravated by very low radiation inversions. Thus, a significant pollution potential exists under these conditions. Secondly, the air mass from the San Francisco Bay Area is known to transport pollutants into Sacramento Valley, and the general pattern from the Mayacmas Mountains may introduce pollutants from The Geysers area into this circulating air mass. Thus, concentration of sulfur containing pollutants aloft over the northern Sacramento Valley requires investigation on a regional rather than local level.

NOISE

Current ambient noise levels over a large portion of the project site and environs have been measured. Ambient or background noise levels are those taken in the absence of the source being studied. Levels measured in the absence of noise due to mechanical equipment or well venting were quite low in the area, generally ranging from forty (40) to fifty (50) dBA. Some portions of Anderson Springs have slightly higher noise levels (50-55 dBA) due to their close proximity to the stream running through it. However, in general, background noise levels throughout the area were in the low forties (40s).

Two sensitive locations have been identified. The first is the Verdant Vales Camp, located in the center of the project site. This is a Christian Scientist camp housing about one hundred and fifty (150) counselors and children during the summer months and a private school for grades seven through twelve (7-12) with about thirty (30) students and ten (10) teachers there during the winter months. The school is approximately five hundred (500) feet from the nearest of the existing wells (McKinley 3 & 6) and about five hundred and fifty (550) feet from the nearest proposed well site.

The second sensitive location is the community of Anderson Springs. The distance from an Anderson Springs residence to the nearest existing well site is approximately twenty two hundred and fifty (2250) feet (the Davies site).

The closest residence to a proposed well site is about twenty six hundred (2600) feet. Noise due to the geothermal operations has been a significant environmental concern to the residents of Anderson Springs for some time. Several residents own sound level meters and regularly make noise level measurements. Sensitivity to moderate levels of noise is quite high among the residents due to the low background levels in the area. This is especially true at night.

There are scattered residences along Socrates Mine Road which are about the same distance from existing wells as the nearest houses in Anderson Springs. These residences are much farther from the sites of the proposed wells, which are to be addressed here, and thus are not considered as critical as those in Castle Rock Springs or Anderson Springs.

Noise due to drilling and venting of wells and truck traffic associated with ongoing and proposed operations will impact these sensitive areas. Details of each source type are described in subsequent noise section of this report.

TERRESTRIAL BIOLOGY

VEGETATION ASSOCIATIONS

A wide variety of vegetation associations is present within the project site. Each association, or plant community, is defined as a unique grouping of flora in which one or more species is dominant. Vegetation associations present within the project site include:

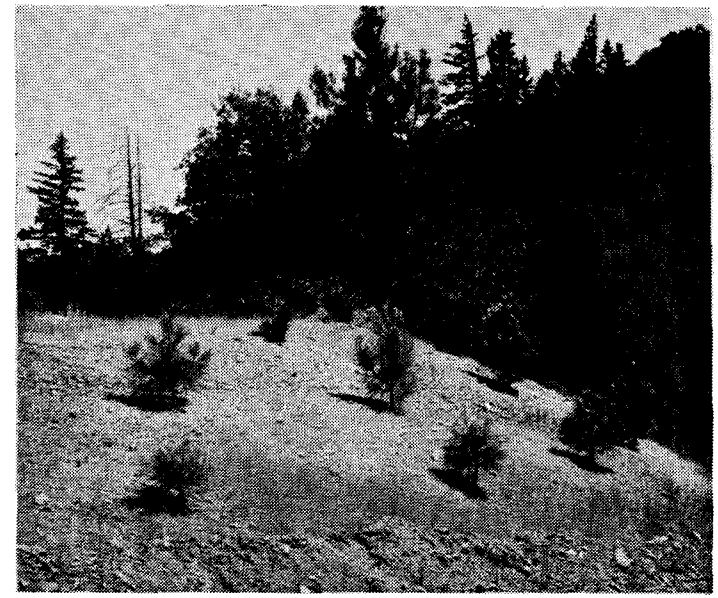
Barren or Cleared Ground
Grassland-Oak
Chaparral
Riparian
Madrone-Oak Hardwood
Mixed Conifer-Hardwood
Knobcone Pine
Cypress

Each plant community is the result of a unique and complex combination of several environmental factors, including fire, soil types, available moisture, exposure, climate, altitude, topography and human influence. Within the project site, available moisture, soil type, exposure and altitude vary greatly and are termed "limiting environmental factors" because they restrict the geographical boundaries of each plant community. For example, serpentine soils allow only a few plant species to survive, creating unique plant associations. These plant associations will also vary in species composition with changes in available moisture and exposure.

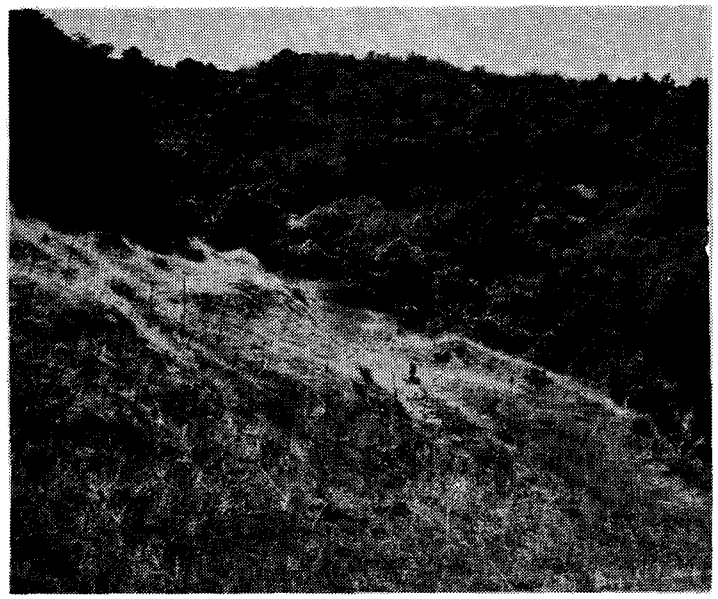
Each of the plant associations within the project site also may be placed into a sequence of ecological succession. In this process each association changes gradually in species composition to become part of the next higher plant community. In transitional zones (ecotones), which are the boundaries between plant associations, the edge of one plant community changes in species composition to become part of an adjacent community. Transitional zones are seldom sharply defined but are gradual as the edge of one association blends into the edge of another. Plant species that are highly shade-tolerant, and which compete successfully for sunlight and available moisture, eventually dominate transitional zones and form new plant associations. The end result of plant community succession is the occurrence of a climax vegetative cover.

In plant community succession, shade-tolerant species seed into the understory of an adjacent community, eventually growing to dominate that association. The climate produced in the understory of a plant community, known as a microclimate, is an important element in plant succession. Douglas fir forests provide dense shade in the understory in which only highly shade-tolerant conifer species can survive. Thus, the Douglas fir forest produces a microclimate which preserves itself as a climax vegetative community. Bay and Madrone species are shade-tolerant in the chaparral understory and with sufficient moisture eventually will

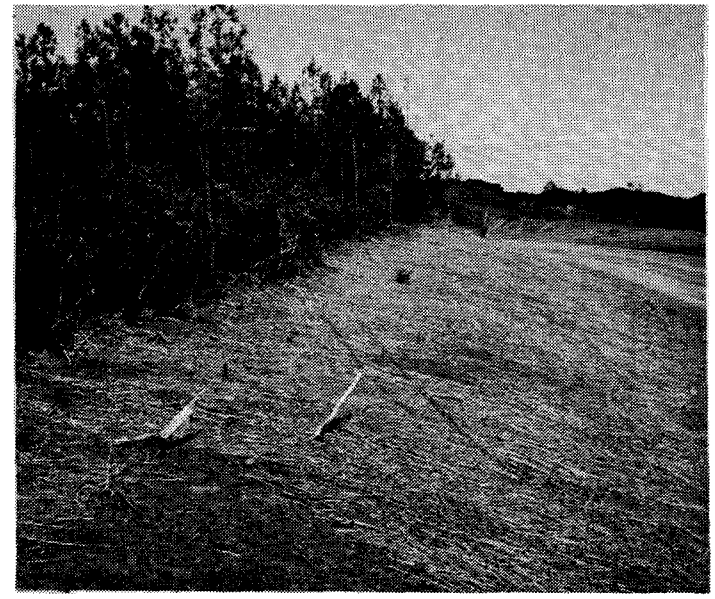
Fill Slope North of McKinley #4



Revegetation of Ponderosa Pine



Grass Cover Southwest of McKinley #4



Revegetation Along Davies Access Road (BLM)

FIGURE 6

Chaparral

Riparian Zone

Madrone-Oak

Riparian Zone Bordered by Grassland

FIGURE 7

Madrone-Oak

Mixed Conifer — Hardwood

Knobcone Pine

Cypress

FIGURE 8

produce a Madrone-Bay canopy, shading out the brush. The Madrone-Oak association, in turn, produces a microclimate in which oak seedlings grow well.

In some locations a climax plant association determined by limiting environmental factors (edaphic climax) will be produced. A climax vegetative association continues to re-establish itself over time, given the absence of fire. On the project site, the climax vegetative cover for most of the area is presently a mixed-conifer forest. Before heavy logging of the project site (1910-1925), and destructive slash fires which followed the logging, a Douglas Fir-Pine forest covered most of the project site. This forest is re-establishing itself as the climax vegetative cover throughout much of the project site.

A discussion of each vegetation association present in the project site follows. The location and abundance of each plant community is also shown on the accompanying map.

Barren and Cleared Ground

A small portion of the project site is characterized by barren and cleared ground. In some areas, rock outcroppings (e.g., Wardlow Rock, Lincoln Rock) prevent vegetative growth. In other locations, smaller rock outcroppings and serpentine areas have meager soil cover and little, if any, vegetative cover. In open chaparral areas in the northern one-third of the project site, particularly west of the Socrates Mine Road and south of Anderson Creek, numerous rock outcroppings exist, supporting sparse chaparral growth.

Talus slopes and barren rocky areas are present on the south side of the Davies access road. Near Big Injun Mine, there are large areas of cleared ground and rock exposures. Sparse vegetative cover is present in these locations.

The majority of cleared ground is the result of development of access roads and drilling pad areas at the project site. Approximately forty (40) acres have already been cleared by construction, with 25-30 acres scheduled for future development. Near the center of the site, ground also has been cleared at Camp Verdant Vales. Grasses have been seeded in on some of the cleared grounds; in other areas, native grasses have established a sparse ground cover.

The Grassland-Oak Community

Found only on the northern edge of the project area, the Grassland-Oak community is a result of a combination of factors, including brush clearing, soil moisture, fire, and soil chemistry. Forbs and annual and perennial grasses form the dominant ground cover. Introduced annual grassland species are a result of the earlier California livestock industry.

The grassland-oak community prevents erosion and holds a thin layer of topsoil. In the transition zone bordering these areas, various brush species and Ponderosa pine are seeding into the grassland-oak community.

The community has one layer of grass, with oak trees (predominantly Valley Oaks) scattered throughout. Due to competition for light, nutrients, and water, the grass understory near the oaks is sparse. In addition, rocky areas and portions of the soil areas are relatively low in available moisture and nutrients, preventing grasses and forbs from establishing a dense cover.

Evapotranspiration, the combined effect of ground evaporation and water transpired by the grass, is high in the grassland-oak association. Only during limited periods, in the spring and fall, is there enough moisture for grasses to produce seeds for the coming year.

The Chaparral Community

The Chaparral community is the most widespread in the project site. This plant association forms a dense vegetative cover, from three to six feet high, with little sunlight penetrating the closed canopy. Hardy brush species live on a variety of soil types and rock areas, surviving on a minimal amount of available soil moisture.

The Chaparral community is structured in two stories. On north-facing exposures Shrub live-oak, Manzanita species, Ceanothus species, scattered Digger pine and chamise form the upper story, with a sparse understory of several grasses and herbs (See Appendix C). On south-facing exposures, usually less dense than on the north side because of higher evapo-transpiration rates and less available moisture, chamise is more prevalent and displays a unique biological form of inhibition, allelopathy, in which it releases volatile toxins. These toxins kill adjacent grasses, thus allowing chamise to invade grassland areas. The presence of these toxins helps to explain the widespread occurrence of Chaparral on the site as well as the limited grass cover in the understory. In addition to the brush species mentioned above, other common species include Toyon, Mountain Mahogany, Coffeeberry and Poison Oak.

Besides the areas of dense Chaparral there are some open Chaparral communities. Serpentine is low in essential Nitrogen-Phosphorous-Potassium nutrients, and the magnesium/calcium ratio is weighted heavily with magnesium; in addition, this soil is highly permeable, allowing winter rains to leach out nutrients. These factors combine to create soils which are unfavorable for plant growth, with the result that these chaparral stands are more open than the stands of dense Chaparral. The brush, which tends to grow in clumps with one species dominating each grouping, grows where sufficient topsoil and moisture are available.

With adequate available moisture and nutrients, Madrone, Bay, and Oak

species will grow to dominate the Chaparral community and shade out the brush. However, in rocky and serpentine areas on which the Chaparral grows, low available moisture and nutrients prevent these species from establishing themselves and shading out the Bay. Only a few Digger pine are found in these locations. For these reasons, the Chaparral cover in serpentine and chert soil areas may be expected to remain on these sites for some time. Here, Chaparral is termed an edaphic climax.

Another factor in the dominance of Chaparral is that it is a "fire-type" association, tending to re-establish itself quickly following a fire. The brush species' root crowns sprout following fire, while their seeds lie dormant until the heat of a fire cracks or scarifies the outer seed coat, stimulating rapid germination. Not only will Chaparral rapidly re-establish itself after a fire, but its surface temperature, which is extremely high, creates a micro-climate suitable for the kindling and rapid spread of fire through the association.

Riparian Community

In the project site, the riparian community occurs within three to nine feet of Anderson and Bear Canyon creeks and several of their tributaries. These riparian areas form narrow corridors which weave through other plant associations. The width of these zones is limited by the little summer rain and hot temperatures which minimize stream-flow.

The riparian community changes significantly in composition from one location to another within the project area. Along Anderson Creek at lower elevations in the project area, the narrow riparian influence extends from five to nine feet on each side of the stream. Structurally, the riparian association at this location consists of three layers. Sedges, grasses, blackberries, wild grapes, and herbs form the surface layer. These species grow from four inches to three feet in height. An intermediate layer consists of bay, willow, redbud, elderberry, and small alder growing from ten (10) to fifteen (15) feet in height. In the upper layer, big-leaf maples, Ponderosa pines, laurel, Madrone, Canyon live oak, Douglas fir, Oak species, and white alders grow from forty (40) to sixty five (65) feet in height.

The tall riparian structure along Anderson Creek is in contrast with adjacent low-lying structures of grassland and chaparral communities. A transition zone, or ecotone, exists between riparian zones and these communities. In this zone a greater variety of plant species exists This species diversity, together with available water, attracts many wildlife species.

With elevation increases, Big-leaf maples are indicator species for riparian zones in woodland communities. In Madrone associations, the riparian community takes on a two-storied structure. In the lower story, herbaceous vegetation, sedges, small oaks, and Douglas-fir seedlings are found. In the upper story, sharing the canopy along with Big-leaf maples (Acer macrophyllum) are Madrones, Canyon live oaks, Black oaks,

Bay, and Douglas-fir trees. Often, the Big-leaf maples will dominate the overstory. Wild grape is commonly associated with riparian areas, climbing onto the branches of nearby vegetation.

At elevations above twenty seven hundred (2700) feet in the project area, the extent and density of riparian vegetation decreases significantly. In cypress or knobcone pine communities, riparian zones are barely noticeable. Bay grow in riparian zones within the knobcone pine areas, while only herbaceous growth and taller cypress species than found in the overall cypress cover are present in cypress communities. At these higher elevations, most riparian zones contain intermittent streams.

The riparian community throughout the project area exists in a delicate ecosystem balance. The preservation of riparian zones is imperative to maintain stream quality, aesthetic values, and vegetative species critical to wildlife survival.

Madrone-Oak Community

This community frequents north-facing exposures within the project area, and forms a wide transition zone between Chaparral and Mixed Conifer-hardwood communities.

Structurally, the Madrone-Oak community is composed of three layers. Herbs and grasses are found on the surface. Nutmeg, bay, oak, young madrone, poison oak, and conifer saplings form an intermediate layer, from 2 to 6 feet high. This layer is relatively easy to walk through, since the former brush species have been shaded out. Both Douglas-fir and Sugar pine seedlings grow in the understory, with Douglas-fir predominating. Sugar pine seedlings are found at higher elevations in this community. An excellent seed source for Douglas-fir and Sugar pine exists on the Wardlow Rock ridge above the Madrone-Oak woodland.

The upper layer of the Madrone structure is from 20 to 35 feet tall. Madrone is the dominant tree species, with oak co-dominant in some areas. Madrones and Oaks grow on relatively fertile soils. These soils retain sufficient soil moisture to maintain the woodland association.

In the early stages of growth in this community, Bay and Scrub Oaks gradually shade out brush species, and Madrone trees seed in. The Bay is shade-tolerant in the Chaparral understory. In turn, Madrone species successfully compete for light, nutrients, and moisture in the Bay-Scrub oak understory. Madrone and eventually Oak trees grow to dominate the earlier communities.

As the Madrone-Oak community provides shade in its understory, a microclimate is developed in which conifer seedlings establish themselves. Adequate moisture is available in this understory for conifer seedlings. These seedlings also do not have to compete with brush species, since the brush has been shaded out by the Madrone canopy. From 2500 feet to 2700 feet in elevation in the Madrone-Oak community, Douglas-fir and

Sugar pine occasionally grow above the Madrone-Oak canopy. Several conifer trees per acre are involved in this successional activity. Eventually, a Mixed Conifer forest will replace the Madrone-Oak community.

Mixed Conifer-Hardwood Community.

This community is located primarily on north-facing exposures in the project area, since conifer and hardwood species require a greater amount of available moisture to survive. (On north-facing slopes, sunlight is less direct, evapo-transpiration rates are lower, and moisture is more available than on south-facing slopes.)

Structurally, this forest has three stories. The lower story consists of herbaceous growth on the ground surface. Bracken ferns may also be found in moist locations. In drier areas and locations with dense shade, the ground cover may simply consist of a humus layer. In open areas of the understory, conifer seedlings are abundant.

The intermediate story is often a dense layer, consisting of oak and madrone trees, from fifteen (15) to forty (40) feet in height. These species are remnants of an earlier Madrone-Oak community. Conifers may be seen growing up through this layer.

The upper story or canopy layer consists of dominant conifer species, including Douglas-fir and Sugar pine. Douglas-fir is the predominant species throughout most sections of the Mixed Conifer-hardwood forest in the project area. Ponderosa pine are located in drier sections of the project area near Anderson Springs, on the northern border near the proposed Pacific Gas & Electric Unit 13 site. Sugar pine are common near the ridge, adjacent to the Thorne #3 padsite and along the Socrates Mine Road above Thorne 3 as the road approaches the proposed Pacific Gas & Electric Unit 13 site. In this area, the canopy consists of up to seventy (70) percent sugar pine. Throughout most of the Mixed Conifer-hardwood forest, the upper layer of conifers has not yet formed a dense canopy. Thus, the Oak and Madrone species have not been shaded out, and form the intermediate story. In some areas of the community, hardwood species share the canopy with the conifers.

In the absence of fire this community tends to maintain itself indefinitely as a climax, gradually becoming a Mixed-Conifer forest. As individual trees die, openings in the forest fill with herbaceous growth, shrub species seed in, and conifer species eventually establish themselves in the understory. As the young conifers grow they shade out most of the understory species, until a dense conifer canopy is again established.

After a fire a variety of successional patterns may occur. Conifer species will eventually re-establish themselves on sites where they existed before, after brush and hardwood species have been shaded out by the conifers. The Castle Rock Springs area was extensively logged from 1910 to 1925, and destructive slash fires swept through the area in 1928 and again in 1946.

Smaller fires have since occurred in sections of the project area. The fact that the conifer forest is only beginning to re-establish itself over portions of the project area indicates relatively recent destruction of this climax community by logging and subsequent fires.

Fire is still a major threat to the Mixed Conifer-hardwood forest. The understory vegetation is presently quite dense in sections of the community; any major fire in the area would soon develop into a crown fire and destroy many of the conifers.

An unusual feature of the Mixed Conifer-hardwood community at the project site is the effect ocean breezes during late spring, summer and early fall have upon the location of this forest.

Near the forestry ridge road above Wardlow Rock, Knobcone pine are found on east-facing slopes, while Douglas-fir grow 100 feet away on west-facing slopes. Soil types are the same for both sites, and both sites have an exposure that faces slightly north. Therefore the effect is not from north or south-facing exposures, or from soil types, but rather from the influence of cool, moisture-laden breezes from fog banks near the Pacific Ocean, forty five (45) miles away. These breezes increase humidity, and reduce evapotranspiration rates on west-facing slopes near the ridgeline. Since Douglas-fir prefer more available moisture, the fir predominate as the conifer cover type on west-facing slopes near the ridge.

Knobcone Pine Community

This community is found at elevations above twenty seven hundred feet (2700) in the project area, both north and south of the Wardlow Rock Ridgeline. Knobcone pine grows on weathered serpentine soils, where moisture is more available than in cypress areas.

Structurally, Knobcone pine stands have either two (2) or three (3) layers. In a three (3) layered structure, a sparse cover of grasses and herbs is found at the ground level. Bay species grow in intermediate layers, from three (3) to six (6) feet tall, while Knobcone pine form a dense canopy layer from fifteen (15) to twenty five (25) feet tall. In the two (2) layered structure, sparse herbs and grasses cover the ground surface, with Knobcone pine growing in a dense canopy. In the two (2) layered structure, the bay has been shaded out by the pine.

Knobcone pine, like Chaparral and Cypress, is a "fire type" association. The community is found in dry areas, and grows to form a dense entanglement of dead branches and pine needles in the understory. This is a perfect fuel structure. In addition, the cones open with the heat of a fire, while the seeds are fire-stimulated in terms of reproduction. The outer seed coat cracks during the heat of a fire, and germinates in the

barren ground. Thus, Knobcone pine stimulates its own reproduction through fire. A hot fire microclimate is also created in the understory, promoting the kindling and rapid spread of fire.

This community grows in a delicate ecosystem balance, with little available moisture and intense serpentine influence in many areas. In these locations Knobcone pine is considered an edaphic climax community; here environmental factors allow only Knobcone pine to survive as a climax species.

The Cypress Community

The Cypress community occurs in areas where soil moisture is low, evapotranspiration rates are high, and serpentine influence is intense. Cypress species have adapted to extremely dry climates. Evaporation from the ground surface is reduced by a dense canopy layer, while the unique, narrow structure of the cypress branches minimize plant transpiration. Structurally, the Cypress community consists of two (2) layers. The lower layer consists of sparse herbs on the ground surface, while the upper layer is a dense canopy of cypress, shading out chaparral species.

Two distinct cypress communities are present within the project area. One area is located at twenty-two hundred (2200) feet in elevation, on north-facing exposures near Anderson Creek. Sargent's cypress grows in rocky serpentine soils on this site to a height of five feet. Manzanita had once covered this area, but has been gradually shaded out by the cypress. The second cypress community is located at three thousand (3000) feet in elevation, on south-facing exposures south of the Wardlow Rock Ridgeline. Both McNabb's and Sargent's cypress grow to form this association. The cover is also more open than in the first cypress location, due to even lower amounts of soil moisture. Cypress grows from three to eight feet tall at this site. Manzanita bushes are found in clumps between the cypress, growing from two (2) to four (4) feet high.

An intermittent stream course borders the northern edge of the second cypress community. Here the cypress species grow into trees, from twenty (20) to twenty-five (25) feet tall. This semi-riparian assocation blends into the pigmy cypress community to the south. To the north, it grades into a knobcone pine-chaparral cover. The striking difference in the height of the cypress at a distance of one hundred (100) feet dramatizes the influence available moisture has on vegetative growth within the project area. The Cypress community, like Chaparral and Knobcone pine, is also a "fire type". Cypress is stimulated, in terms of seed germination and reproduction, by fire.

Fire and Ecology

Fire plays an important role in the ecology of the project area. Much of the vegetative cover at the site is characterized by "fire type" cover. The present cover is indicative of the site's recovery from a major fire in 1946. This was a destructive slash fire, following heavy logging. Many plant species in this area have adapted to fire. Following fire, many brush species sprout from their root crowns. Fire also cracks, or scarifies, the outer layers of Knobcone pine seeds, promoting vigorous germination. Cypress species also display a high rate of recovery following a fire.

Many species in the project area stimulate fire. These species contain fuels with high concentrations of volatile substances, and grow to form "fire fuel structures". In Knobcone pine stands, for example, the dense layer of dead branches and pine needles in the understory forms a perfect "fuel structure" for fire. In Mixed Conifer-hardwood associations, the dense understory, containing dead brush that has been shaded out, forms a "fuel structure". These fuel structures greatly increase the fire hazard.

Some plant communities create a fire microclimate in their understory. In Chaparral, surface temperatures are extremely hot. This reduces humidity to almost zero, and increases the potential for the kindling and rapid spread of fire.

The plant communities on the project site are typical secondary successions following a fire. Many of these associations are actually stimulated, in terms of reproduction, by fire.

Rare and Endangered Vascular Plants

A list of possible rare and endangered vascular plants is found in Appendix E. Several of these species occur in Lake County and one has been identified within the project site. Many of these plants are small annuals or perennials, and can only be identified during a short flowering period. Thus, it is difficult to tell if any other species listed in Appendix E are located within the project area.

The species identified within the project area, Lupinus sericatus, has a distinguished blue flower and is in the Leguminosae family. Lupinus sericatus, or Lupine, is commonly found growing in clumps. Lupines are abundant in the project site, for a rare species. They are found along the Socrates Mine Road, from Thorne Padsite #5 to the ridge. Another Lupine area is found along the access road into Camp Verdant Vales. Lupines are also found along the eastern border of the project site, near Anderson Springs, and heavily populate the northwestern corner of the project site near Anderson Creek.

Atlantis Scientific

VEGETATION ASSOCIATIONS
OF
CASTLE ROCK SPRINGS AREA

LEGEND

SYMBOLS

- Grassland
- Cypress
- Mixed Conifer – Hardwood
- Madrone – Oak
- Chaparral
- Knobcone Pine
- Riparian
- Barren Ground
- 5 — Possible future drill site
- 13

N

0 1000 2000 FEET

FAUNA

Due to the diversity of habitat types, a wide variety of wildlife is found within the project site. Each vegetative association, with its unique combination of plant species and environmental conditions, defines a wildlife habitat type. Each habitat type provides some, or all, of the habitat essentials required by various wildlife species. These elements include: water, breeding and nesting sites, food with adequate nutrition, and cover for protection from predators and climatic extremes.

Each wild bird or mammal is best suited to exist in one or more habitat types. The distribution of habitat areas within the project site dictates local abundance, since nearly all fauna attain higher densities in one habitat type or grouping of habitat areas than in other areas. Thus, the disturbance of one habitat may affect a greater number of wildlife than would the disturbance of another area. In the project site, riparian habitat zones are the most sensitive. Disturbance in riparian areas affects more wildlife species than in any other habitat.

In addition, each fauna species has a defined home range. Some animals defend their home range against others of their own species. In this case, their home range is defined as a "territory". Many mammals and birds range throughout a wide home range, searching for required habitat essentials. Other species live primarily in one habitat area. These include burrowing mammals, several songbirds, and other small wildlife. These species are more vulnerable to disturbance, since they cannot readily adapt to other habitat types.

The greatest possible number of any species which a given area may support, with a variety of habitats, is referred to as the "carrying capacity" for that area. The carrying capacity will vary in any one area for different fauna. If the local population in a particular location exceeds the carrying capacity, some individuals will be forced to migrate to new areas to find sufficient food, cover, and water. If these species cannot migrate, some individuals will be lost as the population re-adjusts itself to the carrying capacity of the area. Most wildlife populations within the project area are approaching the carrying capacity limit.

Fire will cause great short-term wildlife losses, however, fauna will gradually re-establish themselves with the return of vegetative cover.

Because of the unique combination of habitat essentials found within each habitat area, wildlife in the project area will be analyzed in terms of the habitat types they frequent. It should be kept in mind that several wildlife species utilize a number of habitat areas for food, water, and cover.

Barren and Cleared Ground Habitat

Talus slopes, rock outcroppings, and cleared areas support a sparse population of wildlife within the project site.

A variety of snakes and lizards adapt well to the dry climate found in this habitat, and feed upon small rodents, insects, and each other. Coyotes and ring-tailed cats frequent these areas in search of mice, ground squirrels and other rodents. The abundance of rodents is determined to a small degree, by the rock content of the soils.

A wide variety of wildlife frequents several springs in the area on north-facing slopes near Camp Verdant Vales. Springs may be considered a sub-type of this habitat grouping. Species found here are similar to those in riparian zones, including many insects and birds.

Grassland-Oak Habitat

This open habitat, with a variety of grasses and herbaceous plants, provides food for many wildlife species. Black-tailed hare, quail and a number of birds feed on grass species found in this habitat. Field mice, pocket gophers, and other rodents are common. These small mammals are hunted by the coyote, grey fox, ringtail cat, and several birds of prey including sparrow hawks. Few wildlife species are resident to the area. Most wildlife frequent the area for food, while utilizing nearby habitat types for cover.

Transitional zones create an "edge effect" between grassland habitats and adjacent forest or chaparral areas. Along these edges, a greater variety of plant foods utilized by wildlife (see Appendix G) exists. In the spring, an abundance of succulent young grasses and forbs in the ecotone provides nutritional substance for a variety of wildlife.

Deer utilize the grassland habitat for forage in the spring , and eat acorns from the Valley Oaks in the fall. Deer also frequent the "transitional zones" on the edge of the grassland habits. Many browse species grow in the transitional zone, while nearby chaparral cover offers an escape from predators.

Chaparral Habitat

The dense Chaparral canopy shades out herbaceous growth and restricts access, limiting the variety of wildlife in this habitat. The Chaparral area is utilized by birds and mammals primarily as a cover habitat in areas where the Chaparral is adjacent to grassland areas or riparian zones, and a transitional zone is formed. In these zones, grassland habitats provide food, riparian areas supply food and water, while Chaparral provides adjacent cover. These edge areas are valuable to wildlife.

Bird species common to the Chaparral include California quail, Scrub jay, Bushtit, Wrentit, and Mockingbird. These birds feed on various seeds, berries, and insects in the area. Plant shoots, along with seeds and berries, provide food for a number of rodent species. Reptile species which prey on resident rodents include the Pacific rattlesnake, Common kingsnake and Common gopher snake. Western fence lizards are also present. Coyote, Ringtail cat, Grey fox, and Bobcat frequent the habitat area, hunting brush rabbits, birds, and small mammals.

In general, wildlife frequent open areas of Chaparral rather than mature, dense stands of brush. Easier access, more "edge areas" containing a wider variety of food, and increased quantities of deer browse and herbaceous growth characterize open Chaparral areas.

In the spring, deer are attracted to the Chaparral habitat, browsing on tender young brush growth. Preferred species include Ceanothus species, including 'Deerbrush' and "Buckbrush". (See Appendix G for browse species utilized by wildlife.)

Fire increases the value of brush species to wildlife, especially deer. Mature Chaparral stands have limited amounts of palatable browse, while fire stimulates the sprouting of brush species with tender young leaves. Following a fire, excellent deer browse is found in areas of former Chaparral growth. Grasses and herbs also grow well following a fire, providing additional food for deer, rodents, brush rabbits, and quail.

Mixed Conifer-Hardwood and Madrone-Oak Habitats

These habitats provide food, cover, and nesting sites for many wildlife species. Anthropods such as spiders, moths, and beetles form the base for many food chains in the ecological pyramid. These species feed on decaying humus and upon each other.

Amphibians in the forest habitat include newts, California slender salamander, toads, Pacific treefrog, and Western skink. Reptiles include Rubber boa, Kingsnake, Common Gopher Snake, and Pacific Rattlesnake. (Kingsnakes have been introduced into the project area to reduce local rattlesnake populations.) Sharp-tailed snakes also frequent the area, along with the Western fence lizard.

Madrone-Oak and Conifer woodlands provide cover and food for many birds, including Scrub jay, Stellar's jay, Brown Creeper, California and Mountain quail, Black-headed grosbeak, Oregon junco, and Wrentit. California quail are found in all habitat types, while Mountain quail are restricted to woodland habitats. A variety of woodpeckers, including Hairy, Downy, and Red-Shafted flicker, feed on wood-boring insects and other tree anthropods. Pileated woodpeckers and Blue grouse are common visitors to the forest habitat.

Red-tailed hawk, Cooper's hawk, Sharp-shinned hawk, Great horned owl, and Screech owl are common birds of prey. Red-tailed hawks nests have been observed in several parts of the woodland habitat throughout the project area (see wildlife distribution map).

A wide variety of mammals in the forest habitat includes several bat species, Black-tailed deer, an occasional Black bear, burrowing rodents and moles, Black-tailed hare, Western grey squirrels, and Bobcats. Mountain lions are infrequent visitors to the conifer forest within the study area.

Black-tailed deer use the forest habitat for cover, and are abundant in woodland areas within the project area. Estimates for local deer populations average from ten (10) to thirty (30) individuals per square mile for conifer areas, and from sixty (60) to one hundred (100) individuals per square mile for Oak woodlands adjacent to grassland areas. The forest habitat provides forage, cover, and glade areas for fawn reproduction to local deer herds.

Riparian Habitat

This habitat type, although sparse within the project area, provides many habitat essentials for local wildlife populations. The importance of this habitat type cannot be overstated. With increasing development in California, this habitat type is being destroyed at a rapid rate. Its preservation, for the sake of aesthetic values and more importantly for wildlife preservation, is imperative.

Riparian habitat zones in the project area are limited to narrow strips of influence along stream courses. This habitat provides an abundant supply of nutritional foods for many wildlife species. With available water and interlacing cover, the riparian zone is an ideal habitat for these species. During the summer, the water and nutrient content of grasses and forbs stays at a higher level than in surrounding habitat areas. Critical food links in the ecological pyramid are also provided in riparian zones.

Wet meadows are considered a sub-type of the riparian habitat. Meadows are summer areas for many mammals, while waterfowl and other birds frequent these areas in the winter. There are few meadows within the project area, however. Grey foxes have been observed hunting meadow mice in one of these locations.

At the lower trophic levels in the riparian ecosystem, many anthropods, including insects, spiders, and crustaceans, are found. Many food chains begin with these organisms. Fish live on aquatic insects and their larvae, and various birds feed on the variety of insects. Birds are abundant in riparian zones within the project site.

Reptiles and Amphibians are included in the next higher trophic levels of the riparian ecosystem. Bullfrogs and newts are common, together with the Western toad, Pacific tree frog, and Salamander species. Aquatic garter snakes are present, along with the common garter snake. Pacific gopher snake, and Pacific rattlesnake. These reptiles prey upon Meadow mice, Muskrats, Botta pocket gophers, Ornate shrew, trowbridge shrew, and moles. Upper drainage areas provide water and good hunting areas for other predators, including Coyote, Bobcat, Ringtail cat, and Mountain lion. Raccoons and Porcupines also are present in the riparian habitat, as are Opossum and Striped skunk.

Deer migrate along primary wildlife corridors parallel to riparian zones, in search of forage and water. The deer will not approach riparian zones until the sun has set. There is a significant temperature drop after sunset during the summer in the project site, and at sunset the greatest movement of deer occurs near riparian areas. Deer prefer succulent riparian browse species for food in summer months and early fall, when new growth on brush species has lost its moisture content and hardened. Since deer depend largely upon riparian vegetation, the quality of riparian browse species indicates the health of local deer herds. Within the project site, moderate to heavy browsing of riparian browse species is occurring. Heavy browsing of these species indicates that local deer populations are nearing, or have exceeded, the carrying capacity of the area. With continued development in the project site, especially in areas of prime deer habitat, pressure on riparian zones to provide adequate forage for resident deer herds will increase.

Knobcone Pine Habitat

The dry soils and sparse understory vegetation in this habitat support a limited variety of wildlife. Most wildlife species common to the habitat use it only for cover, finding food in adjacent habitat types.

There is an abundance of seeds present, however, attracting Western gray squirrels, Upland game, Townsen Chipmunks, and Sonoma Chipmunks. Numerous rodents also frequent the area, including Botta Pocket Gopher, Trowbridge Shrew, Broad-handed Mole, and Western Mole. Near riparian areas, raccoon, porcupine, and black-tailed hare utilize the Knobcone pine habitat for cover. Many bird species use the dense cover in this area for shelter and nesting sites, and find food in the form of seeds, anthropods, and tree-burrowing insects. These bird species include Hairy and Downy woodpeckers, Red-shafted flicker, Wrentit, Brown Creeper, and Oregon Junco. Sparrow hawks, Cooper's hawk, and Screech owls are common birds of prey. Bobcat and Ring-tailed cat hunt birds and small mammals in this habitat.

Several reptiles frequent the area including the Common gopher snake, Sharp-tailed snake, Pacific rattlesnake, and California mountain king-snake. Amphibians include the Pacific treefrog, active in the spring when moisture is abundant, and red-bellied newt.

Cypress Habitat

A limited array of wildlife is supported by this habitat type. The lack of year-round water in or near this community, together with a hot microclimate and sparse herbaceous cover, combine to limit habitat essentials. These essentials are sufficient to support only several rodents and a few bird species.

Rodent species include the Brush mouse, Dusky-footed wood rat, Sonoma chipmunk, Broak-handed mole, and Botta pocket gopher. Black-tailed deer pass through this habitat area, but the dense stands of cypress severely limit access.

Amphibians are active in late winter and early spring when water is available for breeding. Two species of newts, the Red-bellied and Rough-skinned, along with the Pacific treefrog, are among common vertebrates present. The Western fence lizard, Common gopher snake, and Pacific rattlesnake frequent the habitat.

In the cypress area north of the ridgeline, more wildlife occur than in the cypress habitat south of the ridgeline, at a higher elevation. Moisture is more available in the first area, and riparian zones are closer to the cypress habitat north of the ridge.

Bird species associated with adjacent chaparral areas frequent the cypress habitat. These include Scrub jay, Wrentit, and Rufous-sided towhee. The cypress habitat type has the lowest wildlife population estimates of all habitat types within the project area.

Wildlife Population Densities

Different habitat types, or groupings of habitat types, have different carrying capacity limits for various species of wildlife. The carrying capacity is defined as the greatest possible number of a given species which a given area may support. Wildlife populations within the project area are approaching the carrying capacity of the area.

The Mixed conifer-hardwood forest in this area has a population density for deer of approximately ten (10) to thirty (30) individuals per square mile. (These figures are indicative of high deer populations found in the Coastal mountain ranges north of Santa Rosa.) In the project area, chaparral is the predominant cover type, while little grassland habitat

exists and over sixty (60) acres of woodland habitat is present. Deer populations in this area are estimated to average from thirty (30) to fifty (50) individuals per square mile.

The quality of riparian and chaparral deer browse species is an indicator of the health of local deer populations. Within the project area, moderate to heavy use of browse species by deer is occurring. This indicates that local deer populations are approaching the carrying capacity of the area. These populations are also dynamic, rising and falling with the quality of the habitat. Any abrupt change in habitat quality within the study area would lower the carrying capacity of the area. Since the present level of utilization of browse species is heavy in some locations, resident deer would be forced to migrate to find sufficient forage and water. This, in turn, places additional pressure upon deer habitat zones in adjacent areas, to support an increased population. The total impact would be a reduction in overall deer productivity in and around the project area. Should deer populations exceed the carrying capacity of the area due to habitat disruption, a number of individuals who could not find sufficient water, forage, and cover in adjacent areas or within the project area would be lost.

Population estimates for most bird species, amphibians, reptiles, and small mammals are difficult to determine. Long-term surveys would be required to ascertain these estimates.

With development and subsequent revegetation programs creating new grassland habitat areas, "abundant" populations of California quail, Mountain quail, and Mourning doves are present.

Rare and Endangered Fauna

A check with the California Department of Fish and Game, and the U.S. Bureau of Sport Fisheries and Wildlife, indicates a low probability of rare or endangered species existing in the project area.

However, the Peregrine falcon (an endangered bird species) has been observed near the southern edge of Wardlow Rock, and near rock outcroppings along the ridgeline above Wardlow Rock (see Wildlife Distribution Map). Peregrine falcons have been observed flying south from the ridgeline across the Davies access road. This was approximately three hundred (300) yards east of the Forestry ridge road. On another occasion Peregrine falcons were observed circling the area near Wardlow Rock. These observations were made in mid June 1975.

The above sightings confirm that Peregrine falcons in the general area use the Wardlow Rock Ridge-Bear Canyon Creek Drainage area for feeding. A possibility also exists that an eyrie (nest) is located within this region. Water is located in Bear Canyon Creek and in streams north of Wardlow Rock. Take-off points for soaring and an excellent view of a hunting

area are located on Wardlow Rock, the ridgeline, and in tall Digger pines located on the cliffs above Bear Canyon Creek. All habitat essentials are present for an eyrie site to be established within the project site.

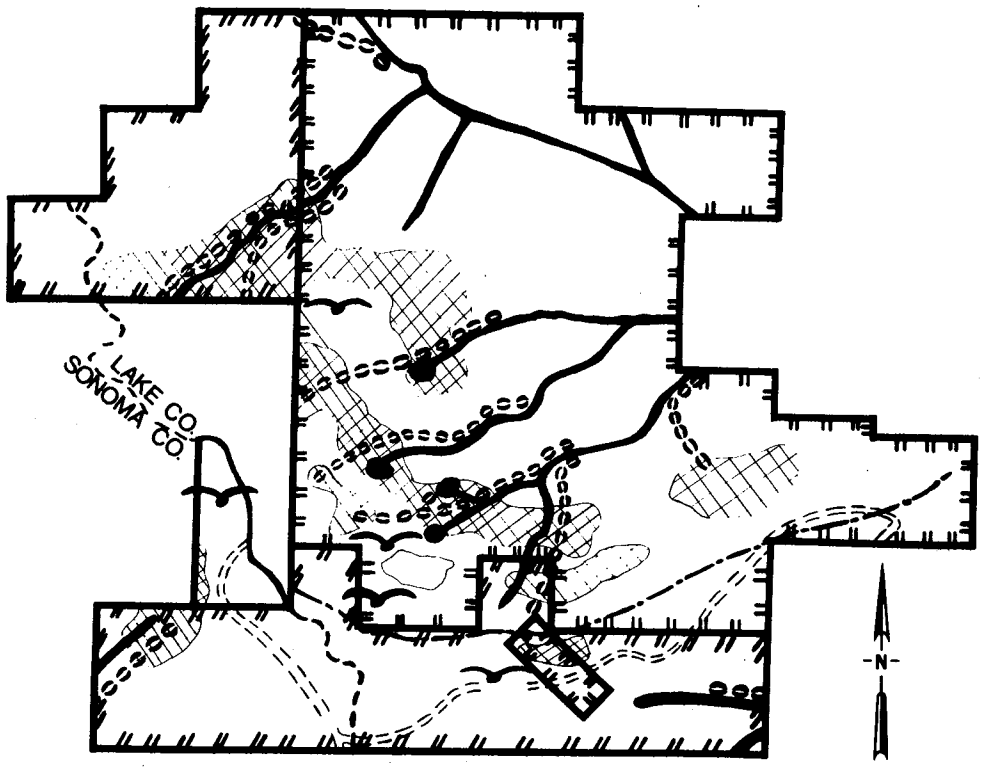
Peregrine falcons have declined in California from one hundred (100) pairs producing young in 1946 to five (5) pairs in 1970. The Federal Endangered Species Act of 1973 sets forth mandates for protection of this falcon. These include the preservation of ecosystems and habitats which the Peregrine falcon depends upon to carry out its life functions. The Federal Government is required to determine the status of the Peregrine falcon in probable habitat areas, and to conduct programs of ecosystem preservation on behalf of this endangered specie. Surveys of the project site and surrounding areas should be undertaken by the California Department of Fish and Game and/or the U.S. Fish and Wildlife Service. These agencies are responsible for the determination of numbers and possible eyrie locations of rare and endangered bird species.

This zone could be a critical habitat zone for the Peregrine falcon, similar to the Linquist Ridge Zone. The recommended surveys would determine the need to enact environmental protection measures for preservation of the Peregrine falcon.

Two large mammals have been observed, adjacent to the project site, (within two years) on the Forestry Ridge Road and might be eliminated without proper consideration. These species are the Black Bear and the Mountain Lion. A wide territory, together with a diversity of habitat types, must be preserved for their survival. Continued development in the Mayacmas Mountains will increasingly endanger the survival of these species.

Other rare wildlife species, whose abundance in the region has not yet been determined, include: Osprey, Long-eared Owl, Burrowing Owl, Pileated Woodpecker, California Thrasher, Western Tanager (abundant several years ago), Black-throated Grey Warbler and Chipping Sparrow. Although all habitat essentials are present within the proposed project site, none of these species were observed. Further research on their local abundance would determine the status of these species.

Other bird species visit the project area only during part of the year, with nesting sites in other locations. A complete list of winter visitors, summer visitors, and occasional visitors (birds with territorial boundaries near the project area) is also found in Appendix F - Birds. These species include Western Flycatcher, Varied Thrush, Yellow-breasted Chat, American Goldfinch, White-crowned Sparrow and Lincoln's Sparrow. Appendix F lists possible rare and endangered birds found within the Project site. The status of reptiles and amphibians, in terms of rare or endangered species within the Project site, is unknown.



WILDLIFE DISTRIBUTION MAP

BOUNDARIES

B.L.M. LEASE AREA

PERMIT AREA

SYMBOLS

SONOMA/LAKE COUNTY LINE

PRIMARY WILDLIFE CORRIDORS

RIDGELINE

RAPTOR NESTING LOCATIONS

RIPARIAN ZONES

PRIME DEER HABITAT

SPRINGS

ACCESS ROADS

FIGURE 9

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

The purpose of the archaeological investigation was to determine the nature and extent of archaeological resources within the project site and to evaluate them with respect to their vulnerability to damage as a result of geothermal resources development.

One archaeological site and several isolated artifacts of prehistoric origin were found within the project site. Additional archaeological sites may have been situated within the area at an earlier time, but extensive development of the area in the historic period has obscured any traces that may have existed. Roads, mining activity, habitation and resort functions, and geothermal well sites have modified the terrain to a considerable extent. Judging from the nature of the terrain and the locations of features favorable for prehistoric utilization, such as springs and other fresh water sources, much of the modern development occurred at locations also favorable for prehistoric use. The archaeological materials that were found, however, allow the suggestion that the leasehold area was employed by the pre-European inhabitants of the general region as a resource procurement zone with habitation more probably situated in more favorable terrain to the east.

In the pre-European period, the Castle Rock Springs region was controlled by the Northern Wappo, who had a major village, Loknoma or goose town, near what is now Middletown (Koreber 1925:219). The Northern Wappo held predominantly the southern headwaters of Putah Creek in Lake County, a triangular area of about eighty (80) square miles with Cobb Mountain forming the northern apex, Mount St. Helena its approximate southern apex, and a point between the drainages of Putah and Pope Creeks its eastern apex. The western Wappo were to the west, the Lake Miwok to the north, and the Central Wappo to the south (Figure 10).

The Wappo were members of the Yukian linguistic stock and were surrounded by Hokan-speaking Pomo and Penutian-speaking Miwok and Wintun. The linguistic diversity of the pre-European peoples who controlled various portions of The Geysers-Clear Lake Known Geothermal Area (KGRA) argues for a complex history of population movements, cultural convergence, and environmental adaptation. On the basis of linguistic evidence, the Penutian-speaking Lake Miwok are believed to have entered their ethnographic territory after the Yukian and Hokan groups were already well established in the area.

Of particular importance with respect to archaeological investigations was the settlement pattern of the Northern Wappo. Settlement pattern, or settlement system, refers to the distribution and function of sites within the territory of the local group as related to demography, resource procurement, internal community organization, and intergroup relations. From the sparse ethnographic record available concerning the Northern

Wappo [7, 38, 80, 85] it is probable that the Castle Rock Springs study area was part of the territory utilized by the Loknoma Wappo of Middletown. Archaeological sites within the study area could be expected to be task-specific associated with food procurement and processing and possibly ceremonial activities. Seasonal camp sites might also be expected, as could an occasional small hamlet, the permanent home for one or two families that lived away from the major town, satellite to it.

A particularly significant archaeological problem that has ramifications well beyond the local region is one regarding territorial boundaries between different local groups. While boundaries in northern California often followed divides between adjoining drainages, the factors which contributed to the locations of particular boundaires are not clear, nor are the mechanisms of local group boundary maintenance. Since the Castle Rock Springs study area is situated close to the boundary between the Loknoma Wappo of Middletown and the Tekenantsonoma Wappo of The Geysers, archaeological study in the area has potential for providing some understanding of the nature of local group boundary dynamics.

Aside from extensive archaeological survey work carried out in association with geothermal resources development, very little archaeological work has been conducted in the vicinity of the study area. Because of different economic foci, it is believed that during earlier time periods settlement patterns contrasting with that of the ethnographic period existed in the mountainous region of which the project site was a part. Details of earlier social and environmental relationships are little known.

A number of different archaeological reconnaissance methods were employed. (1) Records of archaeological sites on file at the Anthropology Laboratory, California State College, Sonoma, were searched, but with negative results for the project site. Several sites were on record, however, for immediately adjacent areas. (2) Conversations were conducted with several local residents. These conversations elicited information regarding their knowledge of the presence of prehistoric remains. All leads so gained were checked out by intensive on-the-ground investigation. (3) A systematic archaeological reconnaissance of the entire project site was conducted.

The project site was covered by an on-the-foot examination that met standards for an intensive surface reconnaissance as described in "Recommended Procedures for Archaeological Impact Evaluation" published by the Society for California Archaeology. Except for precipitous slopes, all areas were examined. Certain features, however, received special attention. These features included flats and terraces; the vicinity of springs; the banks of perennial and intermittant streams; rock outcrops; ridges; and special features such as areas of unusual vegetation.

Cumulative experience in the KGRA has shown that evidence of archaeological sites usually occurs in the form of scatters of obsidian flakes, occasional chert or basalt flakes, and chipped stone artifacts, frequently broken. Milling implements also were found, but bed rock mortars were rare. Midden development occurred at some sites and occasional house pits were recorded. Although rock art, usually in the form of cupules and grooves, has been found in other mountainous regions of the North Coast Ranges, none has yet been found as a result of geothermal-related surveys. A number of specific attributes indicative of the presence of archaeological sites in other parts of Lake and Sonoma Counties appear to be rare or absent near the study area. The most notable absences are fragments of marine and freshwater shell and fragments of animal bone.

Observations on the biophysical context of various portions of the lease-hold were also made, including variables expected to influence choice of location for an archaeological site. These variables included degree of slope, relative ease of access, proximity to areas of gentle slope, scope of overview, situation with respect to climatic and temperature characteristics, availability of water, rock outcrops, and vegetational context.

Landscape damage as a result of roadbuilding, trails, erosion, houses and other structures, hunting camps, resort uses, mining activites, geothermal development, and other recent cultural features was also noted. Much of the modern development had taken place at locations that were also favorable for prehistoric use; for example, areas near springs and other fresh water sources. It is easily conceivable that archaeological sites that once existed in the area had been destroyed by some of these modern features.

Overall, observations made in the project site joined with the ethnographic information regarding the pre-European peoples who controlled it, indicated that the project site was most probably employed as a resource procurement zone with habitation sites more probably located in more favorable terrain to the east. The nature of archaeological finds which were made during the present reconnaissance, described below, tend to support this suggestion.

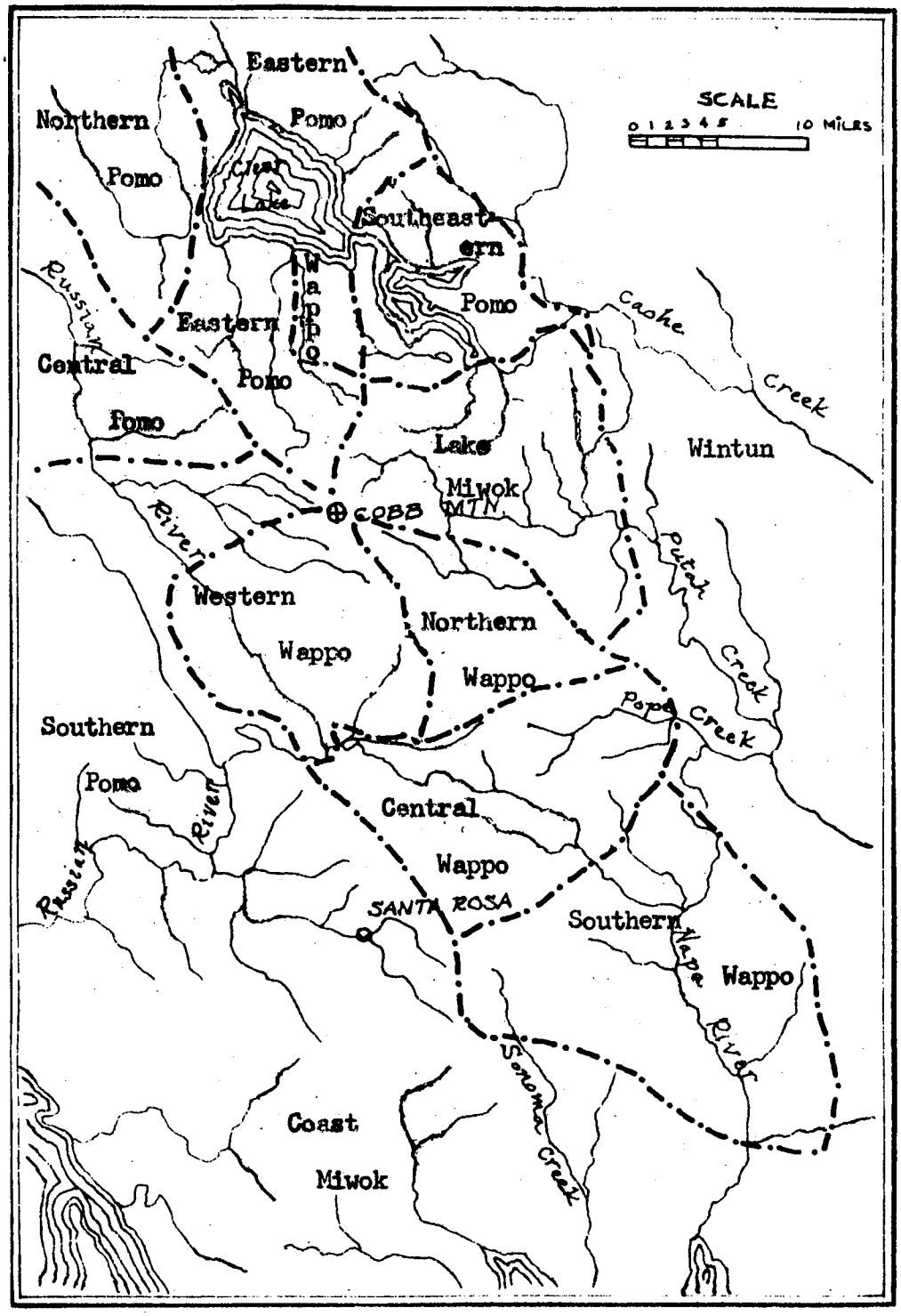
One archaeological site, designated here Geysers 124 (see Archaeology map), the South View site, was found in the leasehold area during the reconnaissance. Four single, isolated artifacts of prehistoric origin were also found within the study area. The South View archaeological site most probably played some role in hunting activities of pre-European inhabitants. The four isolated finds were also probably there as a result of the hunt for game and represent the ancient equivalent of modern-day discarded cartridge casings or spent bullets.

Geysers 124 (South View Site). Site Geysers 124 was located in the NE 1/4 of the NW 1/4 of Section 26, T. 11N, R. 8W, at about the

2240 foot contour on a wide ridge top on the north slope above Anderson Creek (see Archaeology map). A road that trended northwesterly from an origin at Socrates Mine Road passed by the western edge of the site. Geysers 124 was marked by a light scattering of obsidian flakes over an area that measured about 50 by 75 meters. Environmental observations suggested that the site was in an area that would have provided good hunting.

The area in which Geysers 124 was situated was similar in general context to areas in which geothermal steam well drill pads had already been constructed. Since the archaeological site was a relatively fragile surface phenomenon, any development on the scale of drill pad construction could easily destroy the site completely. Even road building or pipeline construction could cause serious damage.

Isolated Finds. Isolated finds of obsidian flakes and tool fragments were found at four locations within the study area (marked A-D Archaeology Map). Intensive search of the find localities failed to reveal any additional evidence of an archaeological nature. Although each find can technically be considered an archaeological site, no site numbers have been assigned them. For the purpose of environmental impact studies, the author usually defines an archaeological site as an area where evidence suggesting some sustained activity is found. This is clearly an operational rather than a theoretical definition. The major scientific importance of the isolated specimens is extracted when each find is accurately recorded as to location and biophysical context. No special precautions or mitigating action need be implemented with respect to these finds.



Tribal Groups in the Vicinity of The Geysers-Clear Lake Known Geothermal Resources Area[85]

FIGURE 10

Atlantis Scientific

ARCHAEOLOGY MAP OF CASTLE ROCK SPRINGS AREA

LEGEND

SYMBOLS

- 124 Archaeological site
- A Isolated find
- B Isolated find
- C Isolated find
- D Isolated find
- 48 Earlier recorded site

5 / 13 Possible future drill site

N

0 1000 2000 FEET

SOCIO-ECONOMICS

This geothermal project is representative of the recent response of utility companies to the rising price of traditional energy sources such as coal, gas and nuclear. As a result of these recent increases in resource costs, geothermal energy has become a viable alternative to other traditional forms of energy production.

The impact of a project of this nature upon both the public and private sector of the local community is varied and complex. There are a variety of burdens imposed and benefits provided. The location of the Burmah development may generate increasing local government revenues and may provide economic growth and stability in the local community. Yet the development is certainly not cost-free. Along with the environmental considerations (which are considered fully in other sections of this report) are the burdens imposed upon local government agencies as a result of increased service requirements in the development area.

An evaluation of the proposed project requires that Lake County carefully balance the positive and negative aspects of the project. It is important to compare the benefits associated with the project to the burdens that such development imposes upon those within the area and those responsible for it.

Adding to the difficulty of project evaluation and rendering the analysis more complex is the fact that this geothermal development is placed within a small county which is experiencing growth for the first time since the turn of the century. Lake County, however, is not unique in this regard.

Development in Lake County is similar in this respect to recent growth patterns of many of California's smaller counties. As these communities were once bypassed for three-quarters of a century (reluctantly or not) while the rest of California's population doubled every twenty years, it finally appears that as the population and industrial growth of the major urban areas are subsiding, the "dormant counties" are now finally beginning to experience some growth pressure of their own.

The recent growth in population for Lake County and two of its neighboring counties supports this fact.

Population

Counties	1960	1970	1975	Increase 1960-1970	Increase 1970-1975
Sonoma	147,375	199,360	244,300	35%	22%
Yolo	65,727	90,794	106,000	38%	17.7%
Lake	13,786	19,700	24,100	44%	22%
State of California	15,717,204	19,779,156	21,030,000	25%	11.5%

The State of California Department of Finance population projections estimate that growth will continue and that the county will experience a doubling of its population during the next twenty five (25) years resulting in a population of over forty one thousand (41,000) by the year 2000.

This growth is a recent phenomenon. Lake, formed in 1861, had achieved a population of only seventy one hundred (7,100) during the height of mining operations in 1890. The contraction of the mining industry brought with it a decline in population, which continued until 1930. Lake has only experienced substantial growth during the past two (2) decades.

Population - Lake County 1890-1970

Year	Population
1890	7,101
1900	6,017
1910	5,526
1920	5,402
1930	7,166
1940	8,069
1950	11,181
1960	13,786
1970	19,200

This population surge in Lake County, which will probably continue if not accelerate, is based upon fundamental pervasive changes in economic activity. A shorter work week, earlier retirement, greater expenditure on recreational activities, and second homes: all have generated an increase in the demand for rural settings, boating leisure activities, and open space activities which are found in the rural counties.

An analysis of the Lake County population change of 1960-1970 reveals that five thousand (5,000) of the six thousand (6,000) growth in population resulted from immigration. The Department of Finance Migration Studies demonstrate that Lake County is a net importer of population of approximately eight hundred (800) to one thousand (1,000) persons per year.

Year 1970-1971	Persons entering Lake	1717
	Persons leaving Lake	636
Year 1971-1972	Persons entering Lake	1755
	Persons leaving Lake	853
Year 1972-1973	Persons entering Lake	2269
	Persons leaving Lake	1362
Year 1973-1974	Persons entering Lake	2540
	Persons leaving Lake	1490
Year 1974-1975	Persons entering Lake	2516
	Persons leaving Lake	1479

Most of the immigrants were from Los Angeles, Contra Costa, San Mateo, and Santa Clara Counties. This increase in population is reflected in Lake's changing ranking among California's counties. While Lake County was 46th in population of the 58 counties in 1960, it was 43rd in 1971. And while it ranked 44th in population density in 1960, it ranked 40th in 1971. The growing population is more representative of elderly persons, the majority of immigrants being over forty five (45) years of age.

The growing population in Lake County is not a wealthy one. Many of the recent studies on Lake County have demonstrated that the median family income is consistently lower than the state average, while the unemployment rate in Lake County is consistently higher than the average. Per capita income for Lake County was approximately $3,000.00 in 1970, which was approximately sixty seven (67) percent of the state average. While Lake County is growing, its growth is that of an elderly, low to middle income retirement population. The county remains below the state average in per capita and family income.

The economic base of Lake County is a limited one. The services sector provides the majority of employment and commerce. Included in the services sector is the tourist industry. Agriculture is the next most important sector, followed by mining/construction and manufacturing.

Employment Groups in Lake County	1960	%	1970	%
Agriculture	779	18	685	12
Mining and Construction	419	10	727	13
Manufacturing	278	6	305	5
Services	2,848	66	4,076	70
Total Employment	4,324	100	5,793	100

Instability in employment and income in the county can result from a highly volatile agriculture sector. Returns to agriculture are dependent upon both weather variables and sharp price fluctuations in the agricultural commodities market.

Fluctuations in agricultural prices generate fluctuations in the value of the county's cash crops which in turn cause instability in the county's economy.

AS REPORTED BY THE DIRECTOR OF FOOD AND AGRICULTURE, LAKE COUNTY

Year	Cash Value of Agriculture Sold from Lake County (millions approx.) (In terms of 1974 dollars)
1963	12.0
1964	15.1
1965	12.6
1966	18.7
1967	17.7
1968	22.4
1969	19.8
1970	13.4
1971	15.6
1972	17.3
1973	23.6
1974	19.6

Though agriculture is a volatile industry, the numbers employed in agriculture have declined, which should result in a more stable employment base.

Though agriculture is declining in importance as a direct employer, it is still vital to the health of the County. A contraction of the agricultural sector (as well as a decline in any sector) results in a multiplyer (indirect) affect on the rest of Lake County and would reduce local income as a result of an indirect affect. For example, studies demonstrate that the agricultural sector purchases approximately seventy percent (70%) of its inputs from within the county.

The local agencies which administer services to the 1,328 square miles of land and 67.1 square miles of inland water consisting of Lake County include the county government, the City of Lakeport, and twenty two (22) independent and twenty four (24) dependent special districts. Despite the recent increases in population, Lake County remains essentially rural. As opposed to its neighboring counties, only fifteen (15) percent of Lake County residents reside within incorporated areas. Services for the majority are provided by county government, county service areas, and special districts.

County	Percentage of Population Residing Within Incorporated Areas
Mendicino	32%
Yolo	51
Napa	56
Sonoma	51
Lake	15

The proposed project is located in an approximately seventeen hundred (1700) acre site in the Castle Rock Springs area of Lake County. The nearest inhabited community is Anderson Springs, located within two miles of the well sites.

Anderson Springs contains a permanent population of approximately two hundred and fifty (250). The residents are elderly, mostly retired, living in cottages and modest homes. Most of the income of the residents in the area is from retirement, social security, and savings. Few are employed or are actively seeking employment.

There is limited tourist activity in the area, though mostly restricted to private hunting clubs on private land. Tourist resorts which were operative at one time have closed. There are some specialized private religious communities in the area which utilize former resort establishments.

The area surrounding Anderson Springs includes some agriculture and forestry activities. Recent development in Anderson Springs has been minimal. In the last decade there has been little development, although a few homes have been built.

The Anderson Springs community receives its services from a County Services District, the Anderson Springs Lighting District, Anderson Springs Water Company, and the Middletown Cemetery and Fire Districts. The Castle Rock Springs area taxes support the County, the Middletown School District and the Middletown Cemetery and Fire Protection Districts.

The local population appears generally favorable disposed to some form of controlled development of geothermal resources. Two of the several opinion surveys conducted to determine the attitudes of local residents towards geothermal development showed the following: One survey included both the communities of Anderson Springs and the Middletown area. (Completed by EcoView Environmental Consultants for Middletown, for Shell Oil Company in January, 1975.) The second survey was undertaken jointly by the College of Natural Resources, University of California and the Planning Department of Lake County. While the EcoView Survey was restricted to the Middletown area, the survey of the University of California and Lake County used as its sample a random collection of registered voters in Lake County. The Middletown Survey reported that thirty five percent (35%) of the respondents definitely favored geothermal development; that fifty three percent (53%) favored development with a qualified OK if the impact of such activity were carefully controlled; that six percent (6%) said no; and that eight percent (8%) did not express an opinion. The results of the poll conducted by the Planning Department also indicated a favorable response to controlled geothermal development in a way most compatible with existing county basic economic resources.

The Middletown residents felt that geothermal development would result in both a decrease in their property taxes by providing more taxes for the county and would result in more economic and commercial activity. The Lake County study found that the respondents desired the county to broaden its economic base and that geothermal development would help accomplish this goal through increased jobs and additional tax revenues.

VISUAL

The project site is on a ridgeline of a small, slightly turning valley approximately two (2) miles long, which lies on an east-west axis. Because of the twisting, forests and the narrow opening of the valley, none of the project site is visible from Highway 175. This highway is proposed for official designation as a state scenic route and corridor.

The project site is visible from a few dwellings in the northwest section of Anderson Springs and the dwellings adjacent to Socrates Mine Road.

Cut and fill banks for roads and pad sites are visible as well as steam plumes and pipelines. The Lake County General Plan calls for the preservation of areas of natural scenic beauty. Increased care must be taken to preserve, protect and maximize the natural beauty of Lake County. The removal or damage of vegetation by grading of land for roads and pads will be minimized by careful placement and prompt revegetation.

CIRCULATION

The past land usage of the site generated minimal amounts of traffic, mostly related to Camp Verdant Vales and visitors to the area. The site is only accessible from Socrates Mine Road which meets Highway 175 north of Anderson Springs. Only approximately one (1) mile of Socrates Mine Road is paved; the rest is gravel and dirt. This road is presently kept open during the winter by geothermal developers crews. Highway 175 is an important two lane road running from Middletown through Cobb Mountain to Lakeport.

The latest available traffic counts (Annual Average Daily Count) on Highway 175 at Cobb Mountain (North of the site) and Dry Creek Cutoff (south of the site) are six hundred and fifty (650) and seven hundred and fifty (750), respectively. The Peak Month Daily Counts at Cobb Mountain and Dry Creek Cutoff are one thousand (1,000) and eleven hundred and fifty (1,150), respectively. This doubling in traffic occurs during the month of August, reflecting the increase in tourism. The Peak Hour Counts at Cobb Mountain and Dry Creek Cutoff are one hundred and thirty (130) and one hundred and forty (140) respectively. The rate of increase in traffic volumes in Lake County as a whole appears to be close to ten (10) percent per year. Highway 175 appears to be presently adequate to meet these traffic volumes.

RADON HAZARD

Minute quantities of radon, a radioactive gas occurring naturally, may be released locally in well tests and venting and at the power plant. Because of the negligible rates of discharge of this gas, no health hazard has been anticipated by the California Department of Health. Surveillance programs developed by PG & E have been considered adequate for monitoring the gas and collecting data about its accumulation around equipment.

Federal regulations regarding occupational exposure to radon-222 in uranium ore processing plants were set by the Atomic Energy Commission (now the Energy Resource and Development Administration). In this standard, the limit on radon "daughters" (nuclides formed by radioactive decay of radon) is set at 7×10^{-8} microcurie of "daughters" per milliliter of air. By comparison, surface water tests conducted prior to nuclear power plant sitings reveal an average natural concentration of 2.7×10^{-8} microcurie per millilites of water, and ground water tests showed natural concentrations of 0.87×10^{-8} microcurie per milliliter of water.

A recent study, prepared for Union Oil Company and PG & E, on Radon (^{222}Rn) emissions at The Geysers has been completed.

The indicated conclusions from this study are:[176]

1. Emissions (point sources) at The Geysers contain concentrations of ^{222}Rn above average, ambient air environmental concentrations (cooling towers excepted). These emissions points are not physically occupiable.

2. Some occupiable areas at The Geysers site show concentrations somewhat above average environmental levels of ^{222}Rn, but not outside of the range of possible environmental levels, and all measured levels except in infrequently encountered off-gas ejector plumes are below 3 pCi/liter. The highest values were obtained in the plumes of off-gas ejectors, at the top of the cooling towers.

3. Population areas around The Geysers were found to have no more than average, ambient environmental concentrations of ^{222}Rn.

4. The near-site environment and population areas near The Geysers did not show any signs of accumulating ^{226}Ra and/or ^{210}Pb in soil, vegetation, or water.

Constant monitoring of Radon and "daughters" will continue at The Geysers and should be implemented in the Castle Rock Springs development area.

RELATED PROJECTS

The Castle Rock Springs geothermal development project does not exist apart from other similar developments. Geothermal activity has occurred in the past and is developing now in and near Lake County. It is part of The Geysers-Clear Lake Known Geothermal Resource Area (KGRA).

THE GEYSERS

Although fumeroles and hot springs were known to exist in the area in the Nineteenth Century, intense activity began only in 1955 when Magma Power Incorporated drilled successful steam wells. Convinced of the economic feasibility of electricity generation by steam, Pacific Gas and Electric (PG & E) entered into an agreement with Magma Power for purchase of steam and constructed a twelve (12) megawatts (MW) generating plant in 1960. Development has continued at The Geysers and today various plants generate almost five hundred (500) megawatts (MW) of electricity.

DILLINGHAM-VOUGHT PROPERTY

Although wells do not currently exist at this site (west of the proposed project), the site is considered the best choice for location of the Pacific Gas and Electric Plant to receive steam from the Castle Rock Springs wells. The plant will require a separate EIR.

DAVIES PROPERTY

An exploratory well has been sunk and evaluation of steam characteristics is under way. Depending upon the outcome of the evaluation, a second well may be sunk and tested.

SHELL OIL DEVELOPMENTS

Shell oil holds leases in the Mayacmas Mountains south of the Castle Rock Springs area. Drilling is underway on several wells, and several geothermal projects are proposed.

SHAUL VALLEY -ELY FLAT

Although not associated with geothermal activity, this area has been the scene of water well drilling conducted by Magma Energy Incorporated. One well was sunk in 1972-1973, and was later abandoned. Permits are on file for additional drilling.

COBB MOUNTAIN

This project, located north of Castle Rock Springs, is on state-owned land on the southeast flank of Cobb Mountain (approximately three hundred and forty (340) acres). It is a leasehold for California Geothermal Incorporated. The proposed project consists of an independent unit, complete with its own steam-gathering system, power generating complex, and transmission lines. No permits to operate have been issued by the State Lands Commission, to date.

HIGH VALLEY CREEK

Union Oil Geothermal Division and McCullough Oil Corporation are undertaking geological and geophysical studies (probes) for location sites of geothermal wells, the installation and operation of support facilities associated with the production and delivery of geothermal steam.

AGRICULTURE

The area east of Highway 175 and south of Anderson Springs has undergone intense agricultural development. Dry farming of oats, barley, wheat and hay occurs. These four crops account for one half (1/2) the total field crops value in the country.

LOGGING

"Selective cut" logging is presently underway north and adjacent to Socrates Mine Road. This twenty (20) to thirty (30) acre site will produce about ten (10) to thirty (30) thousand board feet of Ponderosa Pine (approximately eighty (80) percent) and Douglas Fir (approximately twenty (20) percent). The Davies property south and adjacent to Anderson Springs is presently marked for "selective cut" logging of approximately twenty (20) to thirty (30) acres. This logging operation will probably commence in two (2) to three (3) years depending on the timber market. To date, however, no bids to log have been received.

MINING

Two (2) mines, Big Chief Mine and Big Injun Mine, presently exist on the project site. These two mines are not currently operating.

LAND USE AND RELATED PLANNING

The permit area, with the exception of Sonoma County, lacks a land use designation in the general plan and has no existing zoning. The land in Sonoma County is designated in the general plan and zoned for geothermal developments. The remainder of the project site is on Bureau of Land Management land and is designated for geothermal development. The permit area is privately owned and presently open land which contains timber, streams, and pristine wildlife habitats. Logging has occurred in this region. Recreational land usage occurs such as private fishing, hunting, hiking and picnicking. Mercury mining has also occurred in the area (Big Injun Mine and Big Chief Mine). A year round school (Camp Verdant Vales) is located in the middle of the permit area.

The site is bounded in the east by the unincorporated City of Anderson Springs. This small community is composed of approximately one hundred and fifty (150) single family dwellings, of which one third (1/3) house a permanent population of two hundred and fifty (250). Anderson Springs, surrounded by trees, is located in a narrow valley along Anderson Creek. The west side of the project site is bounded by Sonoma County Geyser Area, which is a productive geothermal area. The site is bounded north and south by open space.

Unlike Sonoma County, Lake County has no zoning nor general plan policies in regard to geothermal developments. Without these two important planning policies, Lake County officials and geothermal operators have little criterion from which to operate. Lake County has adopted (1972) a document titled Conditions, Procedures and Performance Standards for Geothermal Regulation. This document appears to be a temporary action taken until zoning and general plan policies can be activated. Without a land use designation in Lake County's general plan and no existing zoning it is difficult to address land use. However, several sections of the general plan make the following relating planning statements.

- Conservation of lands which provide a valuable source of geothermal power for potential future use.
- The Open Space Element shows Anderson Springs area as recreation-residential.
- Present land uses which result in siltation, pollution of streams should be carefully monitored and if necessary, corrected to assure clean and productive habitats.
- The preservation and maintenance of streams and forests in their natural state to provide wildlife habitat should be an ongoing process.

- Recreation is important to Lake County; therefore care must be taken to retain the natural beauty of the county.

- The recognition and encouragement of the development and enhancement of wildlife habitats should occur.

- The development of industries, businesses and jobs which will attract and hold a young permanent population to Lake County should be encouraged.

- The County Board of Supervisors and Planning Commission should adapt zoning to preserve the beauty and quality of environment in the county.

- The various planning departments within the county should coordinate their decisions between themselves as well as with other levels of government.

The proposed project will conflict with the designation of Anderson Springs area as recreational-residential. The mitigation sections of this report address the question associated with these two land use areas side by side. Mitigation and proper designing measures will be used to eliminate or greatly reduce the impact associated with the proposed land use to retain the natural beauty of the site. These measures are discussed in appropriate sections of this report.

Highway 175 from Middletown through Cobb Mountain to Highway 29 is not presently designated a state scenic route but is proposed for official designation. A state route corridor along Highway 175 approximately one and one half (1-1/2) miles wide is also proposed for official designation. The scenic highway element of the General Plan expresses the need for the adoption of zoning ordinances based on the Scenic Route Plan Principles and Standards which include regulation on land uses, limited access onto highway, tree preservation and setbacks from waters edge. The plan also calls for the application of existing legislative programs and development policy for additional legislative tools to acquire land, open space easements or development rights in scenic corridors. Long term planning maps show Highway 175 as a freeway.

The proposed project will not conflict with the future adoption of zoning ordinances based on Lake County's Scenic Route Plan which includes planning principles and standards to regulate land use adjacent to scenic highways.

PROJECT NEED

A comprehensive analysis of geothermal developmental need is provided in a 1974 EIR, prepared for an adjacent project site.[50] This analysis was based on information provided to the California Public Utilities Commission by PG&E. The proposed project will tap deep steam sources, from an area with geothermal field, for the conversion of heat energy to electrical energy. This electricity will be delivered to residents of Northern and Central California. A brief analysis of the need for the current proposed project follows.

In California's recent past, both the population and overall standard of living have risen dramatically. The State's use of electrical energy has doubled approximately every ten years. Total requirements in 1972 were 155 billion kilowatthours. Recent forecasts by the Resources Agency indicate that electrical energy requirements in California could increase to 355 billion kilowatthours annually by 1985. Actual and estimated sources of electrical energy generation for the 1960-1985 period are shown in Figure 11.

The forecast shown in Figure 11 assumes a continued reliance on additional nuclear and oil-fired plants. No new methods of electrical generation are expected to be in commercial operation before 1985. The growing demand and rising costs of fossil fuels make it imperative that the other methods of generating electrical energy be thoroughly evaluated. Nuclear power construction has fallen behind schedule and it now appears that natural gas will not be available in the quantities anticipated. Energy conservation measures have slowed the growth in demand. Nevertheless, present data indicates there will be significant increases in the demand for electrical energy in California.[175]

The search for reliable energy has turned to domestic geothermal resources. Estimates differ on the ultimate contribution of geothermal energy to the total requirements. However, geothermal energy has been used (by PG&E and by energy suppliers in other nations) to economically supplement base load generation of electricity. Its constant supply and proximity to population centers makes it well suited for this purpose.

The proposed project is an effort to harness a proven resource for generation of electric energy. By worldwide standards, the steam contained at depth in The Geysers-Castle Rock Springs area is clean, abundant and readily tapped. The project site lies within a region of existing geothermal development (KGRA). The site's development for the generation of electrical energy would constitute a reasonable extension of an existing pattern of use and a productive commitment of an open space resource.

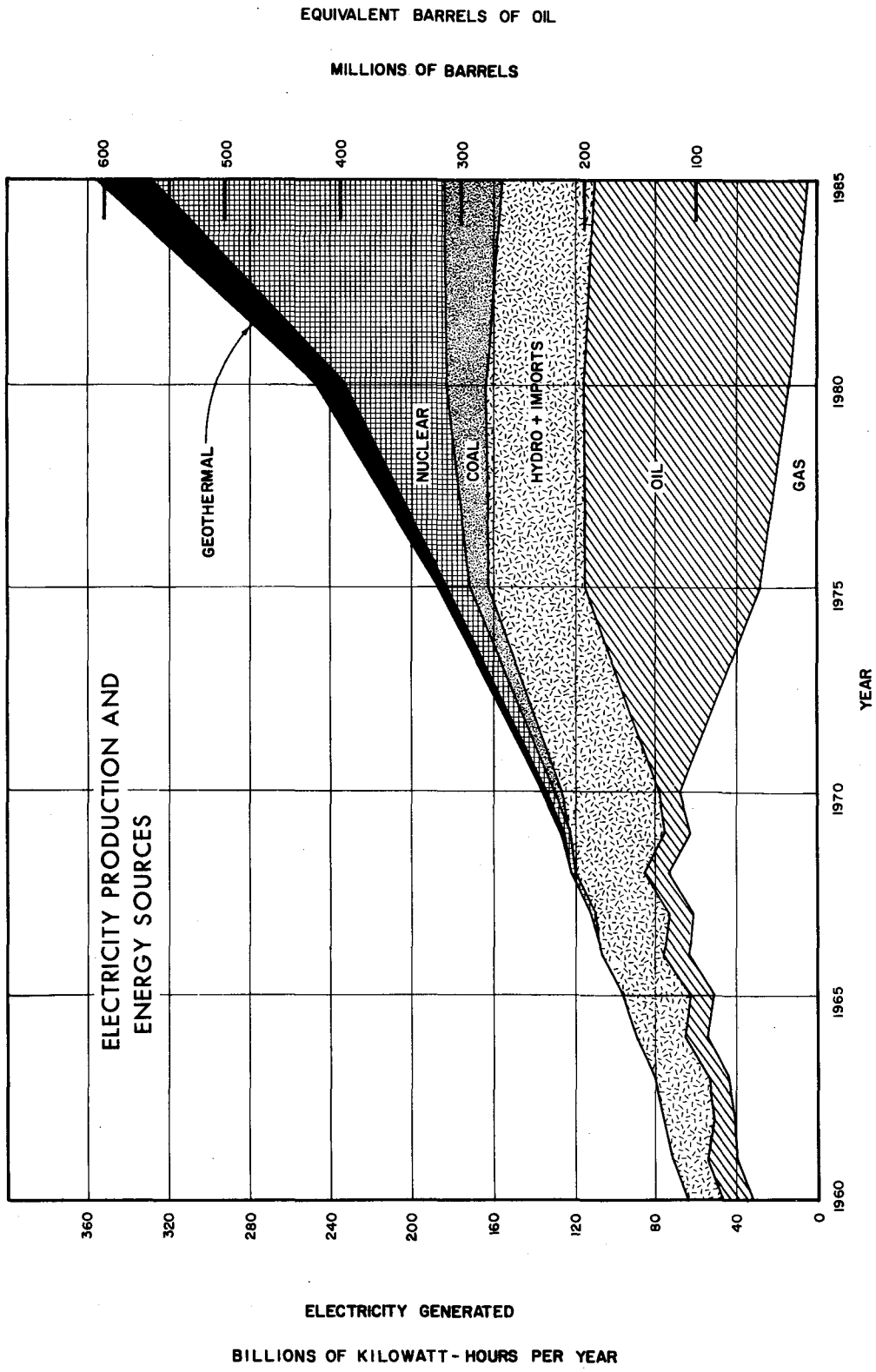

EQUIVALENT BARRELS OF OIL
MILLIONS OF BARRELS
600
500
400
300
200
100
1985
1980
1975
1970
1965
1960
YEAR
GEOTHERMAL
NUCLEAR
COAL
HYDRO + IMPORTS
OIL
GAS
ELECTRICITY PRODUCTION AND ENERGY SOURCES
360
320
280
240
200
160
120
80
40
0
ELECTRICITY GENERATED
BILLIONS OF KILOWATT-HOURS PER YEAR

FIGURE 11

STATEMENT OF THE PROJECT VIEWED FROM THE BOARD PERSPECTIVE OF PUBLIC INTEREST

Development of geothermal resources presents several benefits to society:

- A native American resource can be tapped. Control of the resource resides in internal regulation not subject to foreign manipulation.

- Environmental problems are minimal compared to development of traditional resources. There is no combustion involved; thus hazards involving explosiveness are not present. Furthermore, there are no products of combustion or vast quantities of wastes to discharge. (Technology is progressing on equipment to remove impurities such as hydrogen sulfide from spent steam leaving water vapor as the only principal process residue.) Surface effects are small compared to the land used in mining operations for coal, shale, or uranium.

- Depletion of the resource is not imminent. Fossil fuels have limited lifetimes before they are depleted. The theoretical life of a geothermal resource is not known; however, the only developed geothermal resource in the United States has not been significantly reduced in output of steam since production began fifteen years ago.

- Generation of electricity by geothermal power is competitive with generation from other sources. Whereas fossil costs are steeply rising, geothermal generation costs have risen at a significantly slower pace.

INTRODUCTION

The primary environmental contingencies associated with the proposed project include the following possible impacts: failure of equipment and contamination due to landslides; the increase of surface water runoff due to clearing of pad sites and transmission pipeline routes; contamination of surface water by emissions during construction and possible accidental release of geothermal fluids; erosion due to clearing of pad sites, access roads and pipeline routes; release of gaseous pollutants into the air during testing; generation of dust due to construction of access roads; noise caused by construction, traffic, and well testing; and the demands on community services and on local government itself.

These and other environmental impacts are discussed in the following sections.

GEOLOGY

The proposed actions must be considered in the light of impacts the actions could have on the geologic environment. Consideration must also be given to the possible effects of geologic events (either natural or induced) which could affect the project and indirectly cause impacts on other aspects of the environment. The proposed construction of new well sites, access roads, and distribution pipelines will require grading and modification of existing topography. Direct effects of this grading on the geologic environment could include disruption and/or removal of the soil mantle, accelerated erosion with subsequent siltation and sedimentation and both increased and decreased infiltration of water. Improper grading could also cause slope failures (landslides). Geothermal wells drilled through landslides (either caused by improper grading or naturally occurring) can fail with the resultant "blowout" causing notable damage to the environment. Other potential impacts of the proposed actions include depletion of the geothermal resource and a possible increase in seismic activity resulting from withdrawal or injection of fluid. In addition, the area can be expected to be subject to earthquake-induced ground shaking in the future. Unless facilities are designed to resist such shaking, failure of the facilities would be possible. Foundation failure of any of the proposed facilities as a result of compaction, collapsible or expansive soil would have adverse environmental effects. Sump failure could result in contamination of groundwater. Each of these potential environmental impacts is discussed in greater detail below.

FAILURE OF FACILITIES AS A RESULT OF A GEOLOGIC EVENT

Landslides

Landslides have been responsible for several failures of facilities in the Geysers. Landslides abound owing to the inherently unstable steep slopes. Over twenty-five percent (25%) of the existing wells within The Geysers Geothermal area are believed to be drilled through landslides. Movement of the slides has, in some cases, resulted in "blowouts" of steam wells with attendant environmental damage. In addition, pipelines have ruptured and access roads have required clearing and maintenance as a result of landslide activity.

As areas of past landslides are to be avoided or stabilized during construction of drill sites and as all drill sites will be certified by a licensed soil engineer and certified engineering geologist based on detailed studies, well failure from landsliding should not be a problem with regard to drill sites. Pipeline routes will apparently cross landslides and, as such, could be adversely affected by landslide activity. New access roads will, in general, avoid active landslides and be certified stable. Locally, it may be necessary to cross potentially unstable slopes with access roads. Such roadways could require maintenance in the event of slope failure.

Seismic Activity

The general seismic environment of the site is described above under GEOLOGIC ENVIRONMENT. Earthquake activity has damaged petroleum production facilities elsewhere and could conceivably damage geothermal facilities in the area if they are not designed to resist anticipated seismic loading.

Foundation Failure

Foundation failure of the various proposed facilities owing to collapsible or expansive soils within the area is considered unlikely. These problems are considered and compensated for in design and construction based on the detailed soil engineering-foundation investigation.

IMPACT OF PROPOSED ACTIONS ON GEOLOGIC ENVIRONMENT

Modification of Existing Topography

Grading necessary for the construction of drill sites, access roads and pipeline routes will alter existing topography. It will be essentially impossible to restore the topography to its pregrading condition.

Removal of Soil Mantle, Erosion, Siltation, Sedimentation

Removal of the soil mantle and vegetation by grading will expose the earth materials to accelerated erosion. There is no accurate way to predict the amount of increase in erosion rates, but past experience indicates some increase generally occurs. The increased erosion rate will result in increased siltation of local streams and increased sedimentation. Vegetation will not grow as readily in the areas where soil has been removed.

Infiltration of Water

Graded areas involving cuts will generally allow an increase in the amount of infiltration. Compacted engineered fill, however, is typically very low in permeability; therefore, in fill areas infiltration is generally decreased.

Depletion of the Geothermal Reservoir

The true extent of the geothermal reservoir in the area is unknown. Further, true field life is unknown and even the life of individual wells is uncertain. Prior to installation of a geothermal power plant, studies and estimates are made to determine if there appears to be sufficient steam in the reservoir (roughly wells within a 3000' to 4000' radius of the power plant site) to supply sufficient steam for the plant to operate

for some 30 years, the amortization period for geothermal power plants. It is known that geothermal reservoirs have been exploited elsewhere for over 60 years.

The amount of heat present in the steam and rocks underlying the area is, obviously, finite. Utilization will cause depletion. The rate of depletion and time life of the field cannot be determined until the nature of the reservoir is more thoroughly understood. Further, the rate of depletion may be greatly slowed by injection of water which could produce additional steam.

Increased Seismic Activity from Withdrawal and Injection of Fluid

The injection of fluid into deep wells has apparently caused earthquakes near Denver and Rangely, Colorado.[52+113]. The liquid was injected in these areas under very high pressure. Approximately twenty percent (20%) of the steam produced within the site will be condensed and returned to the reservoir via injection wells. Unsuccessful wells or shallow wells drilled specifically for injection are typically utilized. The locations of injection wells for Pacific Gas and Electric Power Plant Site 13 have not yet been determined, but may be north of the Permit Area. The injection in this area will be under hydrostatic head, not high pump pressure. As such, it appears unlikely that such injection would produce any significant seismic activity.

As noted under SEISMICITY, microearthquakes are common in The Geysers area as well as in other geothermal resource areas. Microearthquakes occur in areas where the geothermal resource has not been exploited.[74] This seems to indicate that the local seismic activity is natural and not associated with development of the steam field. Thus, no significant earthquakes are anticipated to result from development of the geothermal resources in the area.

Sump Failure

Contamination of surface and ground waters has occurred in the past (at The Geysers area), as a result of leaking sumps. Stable, engineered sumps with impervious linings are now required by the Water Quality Control Board and future contamination of ground water from leaking sumps is not anticipated.

Mineral Resources

The proposed development should have no effect on the existing mercury mines within the site. Likewise, the existing mines should not affect the proposed development.

COMMENTS ON POSSIBLE FUTURE DRILL SITES

Five possible drill sites in the southern portion of the Permit Area suggested by Burmah Oil and Gas Company are shown on the Geologic Map. These have been numbered 1 through 5 for ease of reference. While all sites will require detailed investigation by a soils engineer and engineering geologist, as specified elsewhere in this report, following comments can be made with regard to the specific possible sites.

Possible Drill Site 1: This possible site is located south of Wardlow Rock in the Permit area. Topographically, the area appears as a small bench, similar to that which results from slumping. Surface geologic mapping by McLaughlin [10][4] + [11][0] and W.T. Box,[15] however, does not indicate this area to be included within a landslide. Thus, based on preliminary studies, the site appears geologically stable. Owing to the steep and rugged terrain and distance from existing roads, access to the site will be difficult and will require extensive grading. An alternative drill site which could exploit the same area as Possible Site 1 by directional drilling techniques, would be located directly north of the proposed site in the B.L.M. Lease Area on the ridge dividing the Anderson Creek and Bear Canyon Creek drainage. This site also appears geologically stable and access would be easier.

Possible Drill Site 2: This site is located on a ridge south of Castle Rock Springs. This site appears geologically stable but a landslide has been mapped directly to the east. Thus, a careful study of slope stability should be performed. Access to the area will be difficult, but may be feasible from possible Drill Site 3 depending on the condition of the slope above the landslide.

Possible Drill Site 3: This site is located in a saddle and appears geologically stable. Two landslides occur north and south of the site and the potential effects of these slides on the site should be investigated. Access to this site from the Barrows site will be difficult as slopes here average steeper than 2:1. The potential access road should be designed by a civil engineer and the design should incorporate recommendations of the soil engineer and engineering geologist based on a detailed investigation.

Possible Drill Site 4: This site, located south of the Davies Access Road near the Thorne Mine Road, appears geologically stable. Ready access is available from the Thorne Mine Road. This site should require relatively minimal grading.

Possible Drill Site 5: This site is located in the Big Injun Mine portion of the Permit Area. It is apparently located at the head of a landslide (see Geologic Map). This site should not be utilized unless a thorough detail study is completed by a soils engineer and engineering geologist and they certify the site as stable. An alternative drill site could be located approximately two hundred (200) feet south adjacent to the Davies Access Road. This alternate site appears geologically stable and only very minimal additional grading would be required for access.

HYDROLOGY AND WATER SUPPLY

The major impact on water supply in the project area is due to grading and clearing of vegetation around well sites and for access roads. However, such activities are not unique to geothermal operations. For example, similar operations are required for logging activities,[77] where an increase of surface water runoff has been observed. An increase in sediment carried through creeks is expected to accompany this increase in surface water runoff. The sediment is transported to major creeks which provide recreational water for the community of Anderson Springs and can degrade water quality. Spawning of fish can be adversely affected by this increase in sediment.

Some water from creeks may also be utilized in drilling operations, such as in mixing cement, constituting drilling mud and on-site cleaning. It is doubtful that sufficient water is available near the drilling sites to fulfill water requirements for these purposes; therefore, water will most likely be transported to the sites for use.

Surface water may be contaminated by improper disposal of drilling wastes or by mishaps near streams. For example, drilling mud is retained in drilling sumps (ponds) after use. Weathering around these sumps can eventually cause leakage of harmful chemicals into streams with resultant degradation of water quality. Overflow of wastes disposed in the sumps may directly contaminate surface waters.

No major named creeks are close to the well sites themselves, although previously graded access roads from Anderson Springs do cross year-round streams. The project well sites are near two minor unnamed creeks whose headwaters lie immediately north and east of Wardlow Rock. These creeks unite with other small creeks eventually to form a tributary to Anderson Creek, the principal stream running through the community of Anderson Springs.

Little is known of the groundwater in the project area. The few springs that arise are high in temperature and mineral content and are thus useful for recreation or medicinal purposes. Groundwater does not contribute substantially to supplies of potable water in the area. Although wells penetrate near surface strata capable of supporting groundwater, there is little likelihood of geothermal fluids contaminating these zones because the wells are cased as drilling proceeds through the upper zones. Reinjection of geothermal fluids also does not pose a threat to groundwater because of the extreme depth at which injection takes place.

WATER QUALITY AND AQUATIC BIOLOGY

COMPOSITION OF GEOTHERMAL FLUIDS

Condensate analyses from several wells are shown in Table 5. The chemical composition of the condensate varies widely from well to well. Major potentially harmful constituants include hydrogen sulfide, ammonia, mercury and boron.

Hydrogen sulfide

Hydrogen sulfide is present in geysers condensate at sixteen times the toxic level. It is rapidly oxidized to sulfite and sulfate, and may be released directly into the water or returned from the atmosphere in acid rain downwind from the development site. Hydrogen sulfide may be present in streams just above the substrate. It may cause death, retarded growth, extended incubation periods, or deformities in benthic animals, fish eggs, and fish fry. A safe level of less than 0.006 mg /l has been recommended.[134] Sulfide is lethal to Lepomis in one hour at 16 ppm.[67] A sulfate level of 250 mg /l is toxic to humans and similar levels are presumably toxic to aquatic organisms.

Ammonia

Ammonia is present in Geysers condensate at five times the toxic level. Ammonia may be released directly into the water or returned from the atmosphere in rain as ammonium hydroxide. Ammonia is toxic at basic pH at levels of 2.5 to 5 mg/l. The effect varies with oxygen concentration, bicarbonate concentration, pH, and temperature. Rapid oxidation of ammonia may cause significant oxygen depletion, and the nitrates formed will stimulate primary production and cause nuisance algae growth if present for extended periods.

Mercury

Mercury has been found in steam condensate at an average of 0.0027 ppm, with a known range of up to 0.0044 ppm. A concentration of.0333 ppm was found in samples taken near Castle Rock Springs in February of 1975. Mercury tends to vaporize, and is washed down by rain. It is held tightly in the upper two inches of the soil and is removed from surface water by absorption of clays and hydrous oxides of iron and manganese. It may be removed and retained by algae and plankton. The presence of sulfide and reducing conditions will concentrate mercury in the sediments. Sulfur precipitated in condensate at The Geysers has contained 5 ppm of mercury. Methyl mercury is more soluble in organic solvents than in water and is incorporated and accumulated in tissues. Mercury occurs naturally in the springs of the Castle Rock area, and further addition from condensate could be critical. A very tentative safe level of .005 ppm has been set by the U.S. Public Health Service. Mercury may be toxic to fish at 0.004 to 0.02 micrograms per liter.[161]

TABLE 5. Steam Condensate Analyses

	"Thorne" #3[1] mg./l.	"Thorne" #4[1] mg./l.	"Abel" #1[1] mg./l.	"McKinley" #6[2] ppm	Signal MLM #1[3] ppm
Ammonia (NH_3)	1.8	27	23	58	37
Chloride (Cl)	18.0	2	6	12	19
Sulfate (SO_4)	4.0	1	<1	14	20
Bicarbonate (HCO_3)	142.0	-	-	61	193
Sulfide (S)	90.0	22	15	95	110
Boron (B)	0.2	0.1	< 0.1	<0.1	-
pH	6.6	6.6	8.1	8.65	5.77
Iron (Fe)	< 0.01	0.03	0.03	1.0	0.085
Calcium (Ca)	< 0.01	< 1	<1	0.5	0.4
Magnesium (Mg)	0.01	< 1	<1	0.4	-
Sodium (Na)	34.5	-	-	1	-
Aluminum (Al)	7.0	0.13	<0.07	0.1	-
Mercury (Hg)	0.0027	0.00075	0.00047	-	0.0001
Silica (SiO_2)	11.0	0.3	<0.01	0.4	0.3
Total alkalinity	-	38	34	-	-
Potassium (K)	-	-	-	0.2	0.1
Lead (Pb)	-	-	-	0.06	< 0.001
Carbonate (CO_3)	-	-	-	17	1

[1] Burmah Oil & Gas Company
[2] Signal Oil and Gas Company
[3] U.S.G.S.

Boron

Boron in the concentrations present is not toxic to animals, however, plants are much less tolerant, and levels of 2.0 ppm are toxic. Boron could reduce both autochthonous and allochthonous energy inputs to the streams, with consequent reduction in the fauna. Damage to streamside vegetation would be particularly undesirable in the Castle Rock area because of marginal summer temperature conditions.

Thermal loading is another potential impact of release of geothermal fluids. The discharge of heated effluent would raise stream temperatures, stimulating eutrophication and eliminating the trout population.

CHARACTER OF DRILLING OPERATIONS AND ASSOCIATED IMPACTS

Seventeen wells are or will be drilled on the McKinley tract in the Castle Rock area, and several more are being drilled on public lands in the Anderson Creek drainage. Additional wells are contemplated on adjacent public lands in the Anderson Creek watershed.

Road Construction

During the pre-production period of development, several miles of access roads and trails have been constructed. Some light duty roads and trails constructed for field exploration may be abandoned. During test drilling and development phases, roads are enlarged and upgraded to carry heavy equipment such as drilling rigs, air compressors, etc. to prospective well sites. As construction proceeds, roads to well sites are developed further and come into heavy use. All roads are graded dirt and gravel.

Pad Construction

Areas of approximately 125' x 225' are cleared of vegetation and graded flat for construction of test wells. Wells are generally located on ridge tops and flat areas. With further development, one or two acres of ground are cleared and graded. Unproductive wells are capped and abandoned but may be used later for re-injection of condensate. Sumps for holding drilling wastes are dug down-slope from the pads, guarded on the downhill side by earthen dams. These sumps may be constructed on slopes of from 40% to 60%. Surface water is taken for lubrication initially, but the major portion of the drilling operation is accomplished with compressed air. Water may also be withdrawn for human consumption, especially during full-scale construction. Sanitary facilities are of the portable chemical type. Vegetation is also cleared for temporary living quarters.

Wastes from Drilling

Waste lubricant mud from the drilling process is shunted into the sumps. The mud presently in use is mixed from bentonite clay, but drilling lubricants contain toxic substances. Some geothermal liquids are released with the mud. At the completion of drilling operations, sumps are filled and graded. The sump materials, once buried, remain stable unless disturbed.

Catastrophic Release of Geothermal Liquids

Large volumes of geothermal material may be released through equipment failure. Concrete well casings may crack, leading to venting of steam or blowouts, and ejection of mud. Landslides may cause breakdown of wells and/or pipes. At least three blowouts have occurred in The Geysers areas due to inadequate well casing and "minor landsliding". Remedial measures following blowouts may be ineffective. One such blowout in The Geysers area released an estimated 4,000 tons of hydrogen sulfide and 5,000 tons of ammonia over a fifteen year period. Landslides may cause breakdown of sump dams and sudden release of concentrated drilling effluent.

The corrosive nature of geothermal effluent is of major concern in the design of geothermal facilities. Pipes and other equipment are constructed from corrosion-resistant materials. However, failure of equipment which is used for an extended period may occur. At The Geysers facility, although the pipe employed is corrosion resistant, breakdown has occurred at pipe joints causing reversal of flow of reinjected condensate and the release of mud and fluids.

Several thousand feet of pipeline will ultimately be required to convey steam from producing wells in the Castle Rock field to the generating station just east of the crest of the Mayacmas Range in the Anderson Creek drainage. Catastrophic or chronic releases of geothermal fluids will principally flow into Anderson Creek or Bear Creek, although some flow into Big Sulfur Creek is possible. Most wells and other facilities will be sited some distance from permanent streams near ridge tops and other locations which will help protect aquatic ecosystems from direct pollution by moderate releases of fluids. The risks of damaging releases, earthquakes, landslides, blowouts, and other catastrophic events in the Castle Rock area are impossible to evaluate quantitatively with existing information. Prompt remedial action would hasten recovery of stream systems in the event of damage from fluid release.

Chronic Release of Fluids

Production testing involves venting of steam from wells for extended periods as part of the assessment of well potential. Most of the material released with the steam is volatile and dissipates in the atmosphere. Some steam will condense on equipment and drip onto the ground. Venting continues to a lesser extent during later development phases. A large amount of condensate may be released, especially during full-scale

production, if condensate reinjection is not employed. Capped wells must be bled continually to prevent damage to the well, causing the escape of gaseous products and the formation of some condensate.

No data is presently available to quantify the expected impacts of chronic releases from the development, testing or production phases of the Castle Rock area. Experience with the existing Geysers facility suggests that such problems are adequately controlled by good maintenance and the reinjection of condensate, but evaluation on a continuing basis should be maintained in order to develop a better information base.

The U.S. Fish and Wildlife Service, in conjunction with other public agencies and private companies, intends to develop a task force to monitor impacts in The Geysers Goethermal area, including Castle Rock-Anderson Creek systems (Jody Hoffman, Personal Communication). A well designed program of primary data gathering is an absolute prerequisite for an adequate understanding of chronic impacts.

EROSION HAZARDS

As described above, clearing of vegetation and grading of roads and pads will occur during development of the field. Approximately 10 acres will be cleared north and east of the well sites for the power station. These activities will present a moderate to severe erosion hazard. The area receives about 50" of rain annually, over half falling in the months of December and January. A major portion of the upper elevations of the Anderson Creek watershed is composed of Yorkville soils, which are highly unstable and subject to slippage when the subsoils become waterlogged. Past landslides are evident in undisturbed areas at the present time. Obstruction of drainage by roads and pads may increase the probability of landslide occurrence. Landslides are especially hazardous if they result in breakdown of sump walls or damage to existing wells.

Because of the instability of the soil and the nature of the annual precipitation cycle, erosion from roads and pads may be severe, significantly increasing the sediment load of the streams. Suspended sediment in streams causes thickening of gill epithelium and fusion of gill lamellae, inhibiting respiration of fish fauna, especially trout. This may result in death, reduced growth rates, decreased resistence to disease and toxicants, or departure from the site of contamination.

The impact on benthic organisms may be even more significant. Sediment deposition may smother benthic invertebrates, reducing fish food. Abnormal development or death of trout embryos in redds may result from smothering due to sediment deposition. The native rainbow trout population could be eliminated, and the valve of the habitat as a spawning ground for Lake Berryessa trout would be reduced. The intolerant cold water forms could be excluded, while more tolerant warm water species would be unable to invade due to the temperature

regime. The impact of siltation will probably be most severe during the construction phase of development.

The impact of sediment on aquatic organisms varies with species, but levels for rainbow trout should presently be used as criteria for determining pollution levels. Studies on rainbow trout exposed to suspended solid levels have shown a variety of results. Most studies have shown a decreased survival rate at suspended solid levels of 90 ppm.[81] However, one study showed that concentration of 200 ppm may be harmless.[130] Most researchers agree that a suspended solids load of 50 to 60 ppm should be generally acceptable and have very little impact.

AIR QUALITY

The discussion of the environmental impact will include the identification of pollutants, their sources, identification of effects of pollutants present, a review of air quality data, possible effects downwind of The Geysers, and an estimate of local diffusion of significant pollutants.

This region already contains many geothermal wells and power plants, and thus the description of pollutants represents incremental increases in the pollution levels already existing. In addition to the producing wells, there are some natural sources of pollutants in the area. Six (6) additional wells will be drilled and ultimately a power plant to utilize these wells will be constructed.

POLLUTANT SOURCES AND STRENGTHS

The major potential for environmental impact is associated with the production drilling phase although there are some adverse effects associated with the exploration phase, e.g., increased human activity increases potential for brush or forest fires in the region with development of drill sites and access roads with vehicular traffic causing increased dust in the air. Three sources of air pollution are associated with the production drilling phase. Since the drill site must be prepared and leveled and access roads must be developed, there is a certain amount of dust generated and increased emissions from the internal combustion engines used on the drilling equipment. Finally, there are emissions directly from the well itself associated with bleeding the well and standby venting. These sources are examined separately.

It is clear that activities in the drilling region will result in increased particulate matter due to windblown dust. Since the region is mountainous, the drill site location will require leveling and clearing, with access roads. Untreated roads will increase windblown dust in the region. Dust generation as a result of the geothermal related activities will contribute to the degradation of air quality in the vicinity. However, should the impact prove serious, it can be mitigated by watering the road surfaces and drill sites to minimize dust.

Current drilling equipment technology and methods are similar to those used in oil and gas operations with modifications to suit the specific needs of geothermal drilling. For the project site, it is anticipated that a single drilling rig with associated air compressors for the air drilling operations will be utilized during an exploratory program and two (2) or three (3) will be employed during the development drill phase. Also, as many as five (5) bulldozers may be employed for road and well site

construction with a variety of vehicular operations to support the drilling functions. In almost all cases, the engines used on the drill rig, construction equipment, and the vehicular traffic will be diesel engines. Since the main pollutants of the region are hydrocarbons, low hydrocarbon emissions of diesel engines will minimize the impact of these operations. Also, because of the limited nature of these operations, the impact due to hydrocarbon emissions should be of little concern.

A possible major source of emissions in the area is associated with blowouts in which the steam escapes uncontrolled. This situation would pose an environmental hazard. The BLM report [150] indicates that blowouts are expected to be infrequent mishaps due to modern drilling techniques. Nevertheless, such blowouts have occurred in the past and are a possibility due to human error. The possibility of this mishap appears somewhat greater in the test drilling stage than the following stages.

During the production testing and development phases, steam is released from the wells. Noncondensable gases such as carbon dioxide, methane, hydrogen, nitrogen, argon, carbon monoxide, hydrogen sulfide, radon, ammonia, and vapors such as boric acid and mercury, are often released in varying amounts in steam from geothermal sources. Although these gases and vapors make up less than three percent (3%) of the total steam fraction, they can represent a potential air pollution source. Table 6 indicates typical pollutant distribution from wells in The Geyser area.

TABLE 6

Noncondensable Gases Identified in Steam from Wells at The Geysers Power Plant

Gas	Range of Concentrations Measured (Percent by Weight)	
	Low	High
Carbon Dioxide	0.0884	1.90
Hydrogen Sulfide	0.0005	0.160*
Methane	0.0029	0.132
Ammonia	0.0056	0.106
Nitrogen	0.0006	0.0638
Hydrogen	0.0018	0.0190
Ethane	0.0003	0.0019
Total noncondensables	0.120	2.19

*Average from 47 producing wells measured in 1972 was 0.027%.

These noncondensable gases and vapors are emitted into the air during clean out and venting of the steam wells. In addition to steam venting directly from the well site, a much greater amount of steam is released at the power plant. The relative amount of noncondensable gases vented from a typical operation is shown in Table 7. Although power plant emission is not the subject of this report, it should be noted in Table 7 that the major source of pollutants is in fact the steam vented from the power plant without mitigating measures.

TABLE 7

Noncondensable Gases in Steam from The Geysers
(lbs/day)

Gas	Amount from 106 MW Steam Generating Plant	Well Clean-Out	Venting Standby
Carbon dioxide	142,000	3,912	307
Methane	8,400	232	18
Ammonia	8,400	232	18
Nitrogen	2,260	62	4.8
Hydrogen	2,440	67	5.3
Ethane	negligible	negligible	-
Arsenic	0.82	negligible	negligible
Boron	700	19	1.5
Mercury	0.00064	negligible	negligible

Source: PG&E and Enviros

From the analysis shown in Table 6 and the toxic levels of the various pollutants (vide infra), it is clear that hydrogen sulfide and ammonia are the two most prominent environmental hazards, and thus the discussion of the environmental impact will center upon these two pollutants. The Hydrogen Sulfide (H_2S) in the region comes from both natural and manmade sources. Natural sources include springs in the area, while manmade sources include venting from the new wells under discussion and the various wells and power plants currently in operation in the area.

Thus, the values given in this report represent incremental increases in the pollutant level resulting from emissions from the new wells only.

As indicated there are several wells and power plants. The quantities of H_2S to be emitted from the PG&E plants (assuming no abatement) for the next several years are given in Table 8. In addition, Burmah Oil and Gas has 13 wells venting in the Castle Rock Springs area north of the new well sites. These are emitting a total of about 130 lbs of H_2S a day and when additional wells that are needed for the plant are completed, a total of about 200 lbs/day of H_2S will be emitted. Based on data from Burmah, 13 existing wells in the Castle Rock Springs area, on standby, are venting about 4,000 lbs of steam an hour or about 10 lbs of H_2S per day per well.

TABLE 8

Hydrogen Sulfide Emissions from The Geysers Power Plants 1974-78
(tons per day)

Year	H_2S Emissions Without Abatement Program	H_2S With Abatement Program as Scheduled	Total Generating Capacity Available
1974	20 tons	20.0 tons	396 MW
1975	25 tons	20.5 tons	502 MW
1976	36 tons	11.8 tons	718 MW
1977	45 tons	8.0 tons	908 MW
1978	51 tons	5.1 tons	1,018 MW

Source: PG&E and Enviros

About 5.3 miles further west, over the ridge line dividing Lake and Sonoma County, are the first 10 PG&E units at The Geysers which currently produce about 16 to 19 tons of H_2S per day.[49] These latter figures represent maxima since no pollution abatement is considered and full operation is assumed. Based on the above data, the incremental increase in H_2S from the venting of the project wells would be approximately 60 lbs of H_2S per day which is small compared to the background emissions from the above-mentioned production facilities.

Emissions from the venting of the projected wells are based on actual measurements made by Burmah on wells in the Castle Rock Springs field. Other data indicate a spread of H_2S concentrations from 0.005%

to 0.160% by weight and an average from 47 producing wells measured in 1972 as 0.027 weight percent. The Burmah value is approximately .01% which is considerably lower than both the average and the maxima reported from other well sites in The Geysers region.

On a mass basis, the amount of ammonia emitted is approximately 1/4 the amount of hydrogen sulfide. However, due to a difference in molecular weight, this represents only a twofold change in the mole or volumetric percent. Therefore, in terms of the total mass of ammonia added to the atmosphere, one should divide the hydrogen sulfide values by four, but later in discussing the dispersion of pollutants, the concentrations of H_2S are given in ppm (volume fraction). In these cases, the ammonia concentration can be approximated by dividing the H_2S concentrations by two.

ENVIRONMENTAL EFFECTS OF POLLUTANTS

Noncondensable gases such as carbon dioxide, methane, hydrogen, nitrogen, argon, carbon monoxide, hydrogen sulfide, radon, ammonia, and vapors such as boric acid and mercury, are often included in varying amounts with steam from geothermal sources. Of these pollutants, the most serious are hydrogen sulfide and ammonia. Carbon dioxide, methane, nitrogen, hydrogen, and argon are harmless and normal constituents of the atmosphere. Ethane is also present but is highly unreactive and can be considered harmless. The remaining pollutents -- boric acid, mercury, and radon -- if present in sufficient quantities, will cause adverse health effects. The BLM[150] reports that some of the noncondensable gases at the power plant, when mixed with oxygen from the cooling water in the condensers, may be explosive if present in sufficient quantity.

The average concentration of hydrogen sulfide in vented steam is at least one order of magnitude higher than the toxic level permitted by Occupational Safety and Health Association (OSHA), and thus H_2S is an important pollutant. Hydrogen sulfide has an extremely powerful odor resembling rotten eggs and is toxic to humans, and affects vegetation. The olefactory threshold is approximately .03 ppm (the current CARB air quality standard), but there are claims that some persons can detect the odor at concentrations as low as 0.0005 ppm.[50] OSHA has set a toxic level, air quality standard at 20 ppm. Table 9 summarizes the physiological effects of hydrogen sulfide by concentration for several different studies. Although hydrogen sulfide is seen to be a highly toxic gas, it seldom results in fatality, probably because of the powerful odor which gives adequate warning of its presence. However, the olefactory sense should not be relied upon, since it may become insensitive to the odor after prolonged contact.

Hydrogen sulfide can also be injurious to plants. For example, certain plants species in Sonoma County have apparently been affected by the

TABLE 9

Physiological Response to Hydrogen Sulfide Gas Related to Specified Concentrations[136]

Concentration (ppm)	Physiological Response
0.07	Affects light sensitivity of eye
6.7	Chronic toxicity in rats
20	Recommended threshold limit for industrial exposures
50-100	Subacute poisoning, mild conjunctivitis and mild respiratory tract irritation after one hour.
200-300	Subacute poisoning, marked conjunctivitis and respiratory tract irritation after one hour
500-700	Subacute poisoning, dangerous in 1/2 to one hour
700-1000	Possible acute poisoning, rapid unconsciousness and death
1000-2000	Acute poisoning, rapid unconsciousness, death in a few minutes
5000	Instantaneous death
70-150	Slight symptoms after several hours exposure
170-300	Maximum concentration that can be inhaled for one hour without serious consequences
400-700	Dangerous exposure after 30 to 60 minutes
600	Fatal after 30 minutes
100	Slight symptoms after one hour
200	Sufficient to cause symptoms in man
1000	Rapidly fatal

power plant emissions. Preliminary investigations revealed variations of vigor in the foliage of buckeye, big leaf maple, and deciduous oak trees.[150] However, in general it has not been shown to cause immediate pronounced effects on plants when the levels are below those offensive or injurious to mammals. Longer term effects are presently being studied. For example, it is suggested that a concentration of 1.5 ppm for a period of 1/2 to 1 day is a toxic limit for most plants. Table 10 summarizes the effects of hydrogen sulfide gas on plants by concentration. Effects on flora are further discussed in the terrestrial biology section.

TABLE 10

Vegetation Damage Related to Specific Concentrations of H_2S Gas[136]

Concentration (ppm)	Vegetation Damage
1.50	Toxic limit for exposures of 1/2 - 1 day
20-40	Slight damage to a few species fumigated for five hours
400	Some species escaped visible damage after five hours' fumigation

Ammonia should also be considered a pollutant due to its relatively high concentration in the noncondensable gases. The toxic level for ammonia is set at 50 ppm, well above that for hydrogen sulfide. At these concentrations, it has a pungent odor. However, because of its higher toxicity level and lower concentration, it should not be as significant a pollutant as hydrogen sulfide.

The remaining three possible pollutants, boric acid, mercury and radon, are emitted in small quantities. At this time, no toxic level for boric acid has been established, and it is doubtful that this compound would represent a health or safety problem in the geothermal area. Mercury, however, may be present in sufficient quantities to pose a health hazard in some locations and therefore the BLM report [150] does suggest monitoring and analytic work during the production testing phase to determine the potential toxicity. Radon is also released with the steam in small quantities. Recently, the State Department of Health monitored both water supplies and ambient air for radon and its decay products. Results showed that: "No evidence of health hazard was observed as a result of radioactivity in the air and water at The Geysers Resort." Thus, it might be concluded that the radon emissions are not of a sufficient quantity to represent a hazard, but radon monitoring studies are continuing.

CURRENT AIR QUALITY DATA

To date, there have been three monitoring programs near Anderson Springs to determine ambient hydrogen sulfide concentrations. The first was conducted by PG&E in 1972 during the August to October period. The second was conducted by the California Air Resources Board in February and March of 1974. More recently, the ARB has collected data at various locations including Middletown during the April 15 to May 19, 1975 period.[77] Unfortunately, the more recent ARB data is not yet available. These data will be most pertinent since they were obtained during a time which represents a higher pollution potential than the 1974 study and, of course, are more recent. When available, it is suggested that these data be used as addendi to this report to better establish the current atmospheric contamination levels.

The previous ARB monitoring program indicated that there were no detectable H_2S concentrations in the area (i.e., the H_2S levels were below the sensitivity of the instruments being used (less than .01 ppm). As indicated previously, this is not unexpected because the measurements were taken during the winter, which is typically characterized by storms which disperse the pollutants over large areas. However, another characteristic of winter weather is the "dry type" which includes a nocturnal radiation inversion and low drainage winds down the slopes towards Anderson Springs. Possibly this type of weather did not occur during the time of the monitoring program by the ARB.

The PG&E study was conducted during the late summer and early winter of 1972, and thus the results are over two years old. Since then additional units have come on-line at The Geysers and, this data may be significantly out of date. Also, the instrumentation used by PG&E was the COLORTEC H_2S detector. This method gives a good qualitative indicator of the presence of H_2S but little quantitative information. The results of this study showed that during the test period on 6% of the days hydrogen sulfide could be smelled in Anderson Springs and that all incidents of significant H_2S occurred during the summer portion of the study. Study data from other areas similar to Anderson Springs indicated most of the odors occurred during the evening hours. A COLORTEC H_2S detector in the field on the Dillingham propert measured a significant amount of H_2S on 25% of the days.[49] Also, aerial reconnaisance by the Enviros staff showed H_2S odors on calm summer days at altitudes of 5,000 ft which is 2,000 to 3,000 ft above the area power plant.

Enviros also indicated that many of the Anderson Springs residents maintained that air quality is degrading, but this cannot be confirmed due to the lack of monitoring data. However, this is believable since the amount of H_2S emitted into the atmosphere has increased over the last several years.

In addition to the monitoring for hydrogen sulfide levels at Anderson Springs, the ARB, during the same period, sampled the aerosol content using impactors. These samples were analyzed at UC Davis for elemental content. Results of this study show that much of the heavier element particulate matter is soil derived. A similar study, done in the late spring of 1973, also indicated that The Geysers emissions resulted in a significant increase in the sulfur content of the particulate. However, even these increased levels were well below the threshold for health effects established by the EPA-CHESS program. Sulfur aerosols effects can be related to and associated with the gross transport of air masses to regions downwind The Geysers.

GROSS TRANSPORT OF POLLUTANTS

As indicated in the climatology section, there is evidence that during a significant amount of the summer time, polluted air from the Bay area is transported into the Sacramento Valley.[42] Additionally, hydrogen sulfide, which has been identified at upper altitudes above The Geysers area, may be transported into the low speed wind circulation patterns in the Sacramento Valley. The combination of these pollution fields will then move northward into the upper Sacramento Valley. The possible implications of these gross transport patterns are that the hydrogen sulfide emitted from The Geysers will mix into an oxidizing atmosphere with the possibility of oxidation to SO_2 and sulfates.

Thermodynamically, the oxidation of H_2S in air to sulfur dioxide and then to sulfur trioxide, which would form sulfuric acid by absorption in water, would be favored. There is no doubt that this does occur to some extent in the atmosphere. The primary question is the rate at which this conversion can take place. Both the sulfate anion and sulfuric acid are non-volatile materials, and condense from the atmosphere to form particulate phases or aerosols which contribute to visibility reduction or haze. Likewise, sulfuric acid can be a major contributor to "acid rain" which is a significant health hazard.

Several mechanisms have been postulated as possible homogeneous atmospheric transformation processes for H_2S which involve the intermediate ground state oxygen atom [$O(^3P)$], ozone (O^3), and the hydroxyl radical (OH). While $O(^3P)$ atom reacts with H_2S, the rate constant is not very high,[105]

$$O + H_2S \longrightarrow OH + HS$$

and in any case O atoms in the atmosphere invariably combine with the large excess of O_2 to form O_3.

$$O + O_2 + M \longrightarrow O_3 + M$$

The studies of the reactions of O_3 with H_2S were summarized by Glaves and Toby,[63] who suggest that the postulated reactions

$$O_3 + H_2S \longrightarrow H_2O + SO_2$$

may not be sound and suggest two, more complex mechanisms. However, the total reaction is too slow to be significant under the low concentrations present under atmospheric conditions.

Currently, the reaction of OH with H_2S is considered the most likely homogeneous photo-oxidation process during ambient conditions. Even in remote areas, the computed OH concentration can be about 3×10^6 cm^{-3}, [104] while others have observed concentrations around 10^7 cm^{-3} in ambient air.[172] In rural areas, sources of OH result from the formation of nascent oxygen atoms $O(^1D)$ from ozone photolysis.

$$O_3 + h\ (\ 3200\ \text{Å}) \longrightarrow O_2 + O(^1D)$$

$$O(^1D) + H_2O \longrightarrow 2\ OH$$

$$O(^1D) + CH_4 \longrightarrow OH + CH_3$$

Thus, combining realistic estimates of the OH concentration with the rate constant for

$$OH + H_2S \longrightarrow H_2O + HS$$

obtained by Stuhl,[142] the estimated atmospheric lifetime of H_2S is 1.3 days. Cox and Sendalls[35] showed that SO_2 was a major product of the photo-oxidation of H_2S in ambient conditions.

In addition to the homogeneous processes, the possibility remains that heterogeneous reaction, such as the $O_3 + H_2S$ [23] affect the atmospheric transformation of H_2S. Although research in this field is still immature, these processes are likely to be major during background ozone concentrations of 0.002 - 0.003 ppm.

From the analysis, it is clear that the chemical reaction time and transport times are comparable, even considering hydroxyl radical concentrations typical of rural areas. The monitoring data obtained by the ARB at Middletown in 1974 showed that ozone levels were considerably above those required to generate the OH levels described above. Additionally, the ozone and thus the OH levels in the polluted air which has entered the Sacramento Valley from the Bay area will be even higher than that reported at Middletown. Reaction time, therefore, of the conversion of H_2S to SO_2 may be considerably faster than that used in the above calculations. This suggests that there may be strata of increased sulfate (e.g., ammonium sulfate) and sulfuric acid aloft over the Sacramento Valley. During periods of rainout, this could cause

increases in acid rain. To put this possibility in the proper perspective, one can estimate the total amount of SO_2 equivalent to the 20 tons of H_2S per day emitted, and compare this amount to emissions in other air pollution basins. This results in equivalent SO_2 emissions of 15,000 tons per year. In 1970, in the Los Angeles Basin there were approximately 115,000 tons per year emitted, or over eight times the estimate. Thus, although the possibility of increasing the acid rain potential does exist, the incremental increase will be small.

LOCAL IMPACT OF POLLUTANTS

As shown, the main pollutants are hydrogen sulfide and to a far lesser degree ammonia. In evaluating the local impact of these pollutants, one needs to consider both the adverse health effects on the workers who are in the vicinity and nuisance levels upon people living in nearby communities. Standards for operating personnel by OSHA indicate a limit value which should not be exceeded during an 8-hour day at 20 ppm. The olefactory threshold (as set by CARB) is .03 ppm. Concentrations near existing generating units at The Geysers have been measured from 5 to 10 ppm.[150] On one occasion, during the startup of Unit 7, a concentration above 20 ppm was measured in the working area of the plant.[150] Monitoring data is very sparse downwind from the particular operations considered herein, but that which does exist indicates that hydrogen sulfide levels are below the detectability limit. Estimates of the incremental increase in the H2S levels as a result of vented steam from the six (6) proposed wells are analyzed herein. It is recommended that when the results of a more recent ARB study for Anderson Springs are available, incremental changes be applied to the background data supplied in that report.

To estimate H_2S levels to be expected downwind of the proposed project, a simple Gaussian dispersion model was used. In this model, concentrations of the chemically inert pollutant (H_2S) are represented by a Gaussian bivariant distribution, which yields a simplified analytical solution to the transport equations through the additional assumption that diffusion coefficients are invariant in the vertical and horizontal directions (i.e., atmospheric turbulence is homogeneous and stationary). The derived equations are partly phenomenological, (i.e., some of the parameters in them must be evaluated from experimental observation). These include the turbulent diffusion coefficient (represented by the standard deviations of the Gaussian distribution) in the horizontal and vertical directions as a function of atmospheric stability and downwind distance from the source.

The Gaussian plume model is used to evaluate ground level, hourly concentration patterns for the hydrogen sulfide emitted. For this analysis, the horizontal and vertical turbulent diffusion coefficients were obtained from empirical correlations by the Brookhaven National Laboratories [132] which closely approximate the empirical results put

forth originally by Gifford. These latter correlations are more universally accepted, however, the Gifford's stability classes are well supported by Brookhaven classes given in analytic form, therefore simplifying computer inputs. In addition, steam rise due to buoyancy force of hot gases entering cooler atmospheres is computed by an empirical formula developed by CONCAWE.[141]

The Gaussian dispersion model requires the determination of various meterological conditions under which diffusion occurs. These are primarily atmosphere stability, windspeed and direction, and the inversion height when an inversion layer is present. As indicated in the previous discussion on climatology, local winds are probably dominated by the local topography of the area. The proposed wells are on the eastern downslope leading directly into Anderson Springs. Thus, a significant wind pattern will be the establishment of drainage winds down the slope directly through the well region to Anderson Springs. Such a wind condition probably would occur in the evening, and this is consistent with monitoring data taken in similar regions that indicate higher H_2S levels in the early evening. However, during the winter time there may exist radiation inversions during the early morning hours. Should a radiation inversion couple with the downslope drainage winds, this would be considered a most adverse air pollution situation and thus this condition was modeled. Since the morning inversion and the downslope drainage situation may be an improbable situation, the effect of radiation inversion was also investigated. In particular, the meterological conditions shown in Table 11 were considered in the diffusion analysis. The wind direction chosen goes directly through the well area to the western end of Anderson Springs, and was selected to represent the most adverse situation.

TABLE 11

Meteorological Conditions for Dispersion Modeling

Case	Wind Speed mph	Stability Class	Mixing Height feet
1	2.2	neutral	150
2	2.2	neutral	1500
3	6.0	slightly unstable	150

Case 1, the basic adverse condition, yielded hydrogen sulfide concentrations in Anderson Springs directly along the wind vector of .008 ppm and in the eastern section of Anderson Springs of .003 ppm. Case 2, which indicates the role of the low inversion layer of Case 1,

yielded comparable results of .006 and .002 ppm, thus indicating a small reduction in the anticipated concentration with increased inversion heights typical of late afternoon and evening. For comparison, Case 3 was run at a higher wind speed of 6 mph and a stability class which is indicative of increasing mixing below the inversion base. The results of this analysis indicated .002 ppm at both of the Anderson Spring sites. Based on the above analysis, the incremental increase in the hydrogen sulfide levels in Anderson Springs due to the venting of the 6 projected wells would be expected to be well below the ARB olefactory threshold.

A far more significant effect might be the higher levels of H_2S experienced by the working personnel immediately adjacent to the well sites. It was found for Case 1 meteorological conditions that the peak incremental increase in H_2S concentrations occurred about 60 ft. downwind of a centrally located well where incremental concentration was 1.2 ppm. This concentration level dropped off to approximately 50% that value within 160 ft. from the source. There was no effect of inversion height at such short distances from the source. Clearly, the incremental increase in the hydrogen sulfide concentrations is well above the olefactory threshold, yet well below the value indicated for toxicity limits.

In summary, it would appear that the increased H_2S concentration in Anderson Springs due to the venting of the proposed wells would not seriously affect the air quality in Anderson Springs. However, the areas immediately adjacent to the wells will have concentrations which are above the olefactory threshold, but considerably below toxicity limits. Most of the emissions due to venting of steam occur at the power plant which was not considered in this discussion. Consequently, the major impact on the air quality of the region will be caused by the power plant, and thus the above results based on the well emissions are not unexpected. It is important, therefore, to site future power plants in a most advantageous position to minimize impact on Anderson Springs. In order to do this effectively, one needs meteorological data for the Castle Rock Springs area, and thus it is recommended that a monitoring program be established prior to the siting of the power plant.

NOISE

The assessment of noise impact due to the project will be presented in three steps: 1) The determination of the noise levels both at the source and at the impacted areas, 2) The examination of appropriate criteria by which impact may be evaluated, 3) The assessment of the degree of impact based on the considerations of 1) and 2).

NOISE LEVELS ASSOCIATED WITH THE PROJECT

A number of different noise sources will be associated with the geothermal drilling and other operations proposed. Basically they fall into two categories. The first is noise associated with high velocity gas flows exiting into the atmosphere or through pipes. The second is mechanical equipment, primarily engines. In order of severity these sources are:

Noise Sources

Activity	Frequency of Occurrence
Well test venting	8 hours/ 4 days /well
Steam blowoff during drilling	3-7 days/well
Air drilling rig	2-3 weeks/well
Mud drilling rig	1 week/well
Truck and construction equipment	intermittant
Venting of standby wells	continuous
Flow through pipes to power plant	continuous after plant completion

In the following discussion of the noise levels associated with the various drilling activities, some assumptions are necessary. Since the exact drilling sites have not been precisely determined there is considerable variation in distance, topographic considerations, etc. For purposes of discussing impact by means of projected noise levels, it is assumed that the wells nearest to the sensitive locations are producing the noise. The nearest proposed well to Anderson Springs is about 2600 ft. away and the nearest to Verdant Vales is 550 ft. away. Thus, the noise levels calculated in the following sections represent the worst case as far as the proposed well locations are concerned.

Well Test Venting

The venting of a well is accomplished by opening the well valve and allowing the maximum amount of steam available through the pipe to escape. Venting occurs during the first month after a well has been completed for about four eight-hour days in order to test the well and to clear out the well, and periodically thereafter. Figure 3 is a photograph of this process, taken at the recently completed well CA 956-1 during a test. A tapered cone was being used to expand the flow before exiting. The pipe diameter into the cone is about 10 inches. It expands by means of a 3° taper to 30 inches at the exit, 30 feet downstream. Noise levels generated by this process are typical of mach 1 free jet exhausts and are shown in Figure 12. Most of the noise is generated in the air in what is called the turbulent mixing region, 3 to 8 exit diameters downstream from the nozzle. There is a significant directivity to the noise distribution, it being primarily focused downstream. This characteristic can be used to advantage in directing the stream away from sensitive areas.

Noise generated by free jets increases with the eighth power of the jet velocity and with the square of the characteristic dimension, which in this case is the diameter of the exit. Typical levels shown in Figure 12 yield approximately 128 dBA at $\theta = 60°$ and 50 feet from the nozzle. With normal unattenuated geometric spreading this would result in levels of 94 dBA, 2600 feet away. In the actual field tests measured, there was about 20 dBA of directivity attenuation, 15-20 dBA of shielding due to hills and berms, and another 10 dBA of attenuation due to atmospheric absorbtion, wind focusing, ground cover, etc. These effects reduce the noise levels heard in Anderson Springs beyond that which might be normally expected due to simple geometric spreading. This situation is illustrated in Figure 13. Frequently, however, some of these attenuating mechanisms are not effective.

Atmospheric attenuation is a good example. The oxygen molecule is an effective absorber of high frequency sound. During periods of high relative humidity (foggy weather, for example) water molecules in the air prevent the oxygen from effectively absorbing the sound and thus there is a great deal less attenuation due to this effect.

Wind focusing is another example. Sound rays (the path which a sound wave takes) are focused upwards in an upwind direction and downwards in a downwind direction. This effect would produce a beneficial result as far as Anderson Springs residents are concerned when the wind is from the east, or northeast. When the wind is from the west or southwest this downward focusing could have a compound effect. Not only would there be no attenuation due to upward focusing, but rays which left the source horizontally and were thus not

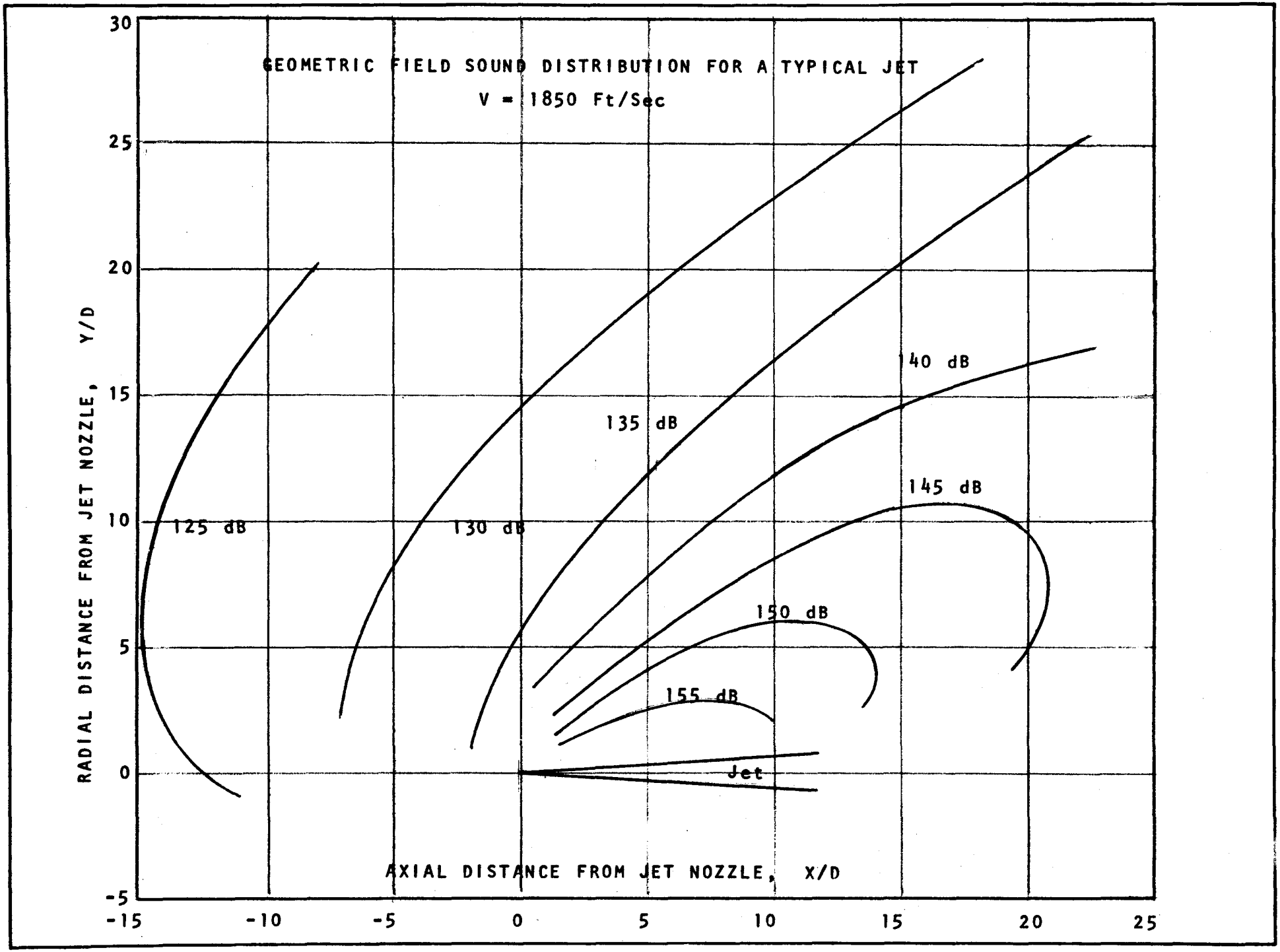

GEOMETRIC FIELD SOUND DISTRIBUTION FOR A TYPICAL JET
V = 1850 Ft/Sec
125 dB
130 dB
135 dB
140 dB
145 dB
150 dB
155 dB
Jet
RADIAL DISTANCE FROM JET NOZZLE, Y/D
AXIAL DISTANCE FROM JET NOZZLE, X/D
30
25
20
15
10
5
0
-5
-15
-10
-5
0
5
10
15
20
25

FIGURE 12

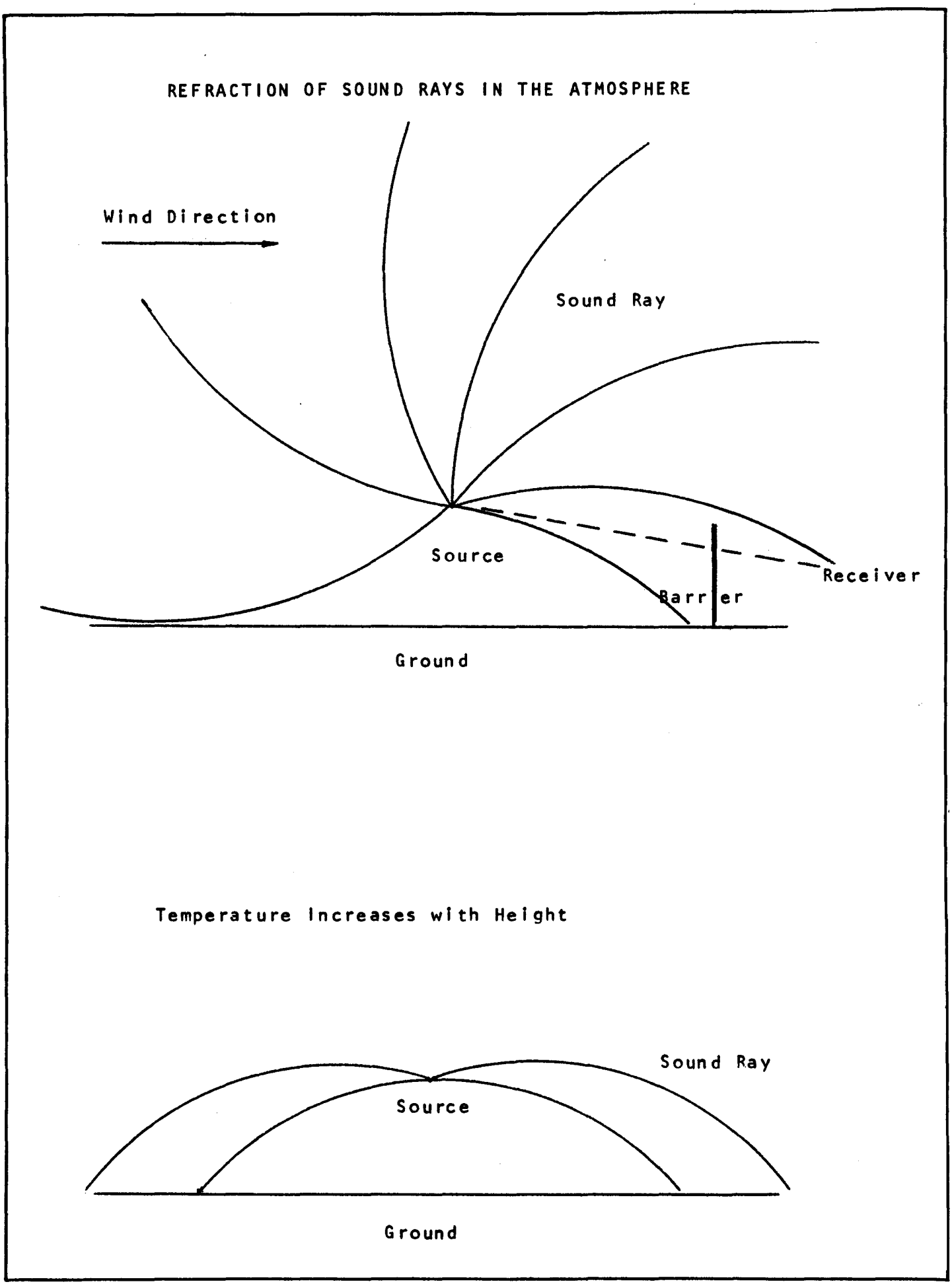

REFRACTION OF SOUND RAYS IN THE ATMOSPHERE
Wind Direction
Sound Ray
Source
Receiver
Barrier
Ground
Temperature Increases with Height
Sound Ray
Source
Ground

FIGURE 13

attenuated by berms or hills, could be focused downwards, resulting in noise levels in Anderson Springs of 75 dBA or more when combined with high humidity. If the jet flow were not directed away from Anderson Springs, even higher levels could occur.

A similar condition could result from a temperature inversion which is also a downward focusing mechanism, especially in combination with fog and a west wind. Temperature inversions (conditions where the temperature increase with height) are especially common at night.

Thus noise levels in Anderson Springs due to typical well (2600 ft. away) venting activities, with flow direction away from the town, could vary from 39 dBA (virtually unnoticeable) in the best possible case on a hot, dry day with an easterly wind, to above 75 dBA in the worst case on a foggy day with a west wind and a temperature inversion (which might occur if the fog was low lying and the sound source was above the fog level). Normal or typical conditions would depend on the microclimatological conditions characteristic of the region. Levels reaching Camp Verdant Vales from a well 550 feet away might vary from 68 dBA to 98 dBA during venting, depending primarily on flow orientation and intervening topographical features.

Steam Blowoff During Drilling

Drilling operations might strike steam at a depth of 3000 ft., for example. At this depth the volume of steam necessary for a productive well is not sufficient and drilling is continued until satisfactory volumes ar e obtained, often at 6000 feet or more. During the drilling process, after steam is initially found, the well must be continuously vented. The venting now takes place through a tangential separator muffler shown in Figure 3 . Although there is no dissapative material within this device, it can provide 10 dBA or so of attenuation. The attenuation of these mufflers depends primarily on the area expansion ratio (ratio of the maximum cross sectional area to the input pipe diameter), which in this case is about 7. If this ratio were increased to about 16, for example, about 20 dBA reduction would be achieved.

The steam exhausted from this device will still exhibit a noise directivity similar to that of the conical diffuser flow. Noise levels will be stronger downstream than upstream and a maximum will occur at an angle of about 40° to the exhaust axis. Typical contours for this type of device are similar to those shown in Figure 13 . These contours were developed based on measurements taken by Burmah Oil personnel. Care must be exercised to assure that what is gained in attenuation due to expansion of the flow in the muffler is not lost due to the vertical exit direction.

Noise propagating away from this source will decrease 6 dBA per distance doubling and will be dependent on the same climatological variations that were previously discussed. Thus noise levels in Anderson Springs could vary from a worst case of 70 dBA with no water flowing through the muffler in adverse climatological conditions to 35 dBA under favorable conditions. The variation is less here than in the diffuser case since the exit direction is fixed upwards. Verdant Vales might be subjected to between 58 and 84 dBA due to this phase of the drilling process from the nearest well, approximately 550 feet away.

Air Drilling Rig

The air drilling rig is pictured in Figure 3. Compressed air is used as soon as possible after the drilling has been initiated (normally one week) to cool the bit and bring up tailings. Noise levels generated by this rig were 102 dBA at 50 feet. There is little directivity associated with this engine generated noise.

Levels in Anderson Springs due to these engines and compressors could range from 68 dBA in an exposed site under worst case conditions to 38 dBA under favorable conditions. Noise levels at Verdant Vales could range from 72 dBA to 52 dBA.

Mud Drilling Rig

During the initial drilling process, mud is used as a coolant and sealant for the sides of the drilled hole as it passes through the water table. This mud is forced into the hole by means of pumps driven by the diesel engines shown in Figure 3. The diesels emit noise levels of 91 dBA at 50 feet. The engines which power the rotating bit produce 86 dBA at 50 feet. This phase of the drilling process is relatively quiet when compared to the other activities. Levels due to this source could range from 57 dBA in a worst case condition to 27 dBA with favorable conditions. Noise levels at Verdant Vales could range from 61 dBA to 41 dBA during this phase of the drillings.

Truck and Construction Equipment

Truck traffic carrying equipment and supplies, watering the dirt roads to prevent dust or moving the drilling rigs and gear, occurs on Socrates Mine Road and the connecting Ridge Road daily. Caterpillar tractors and drag scoops are used to build roads and clear the drilling sites. Truck cranes are used to lift the drilling equipment onto the transport trucks. The use of this equipment is intermittant

and distributed along the roadways.

Figure 14 shows noise levels typical of the various pieces of construction equipment. Noise levels due to trucks at the site fell into the lower half of the truck bar graph shown in the figure. The moveable cranes operating at the site were approximately average. Burmah scrapers, graders and tractors were not in operation during the audit period, so predicated data must be used. Socrates Mine Road is well separated from sensitive locations so that significant impact is not anticipated. Maximum intermittant noise levels in Anderson Springs due to trucks along Socrates Mine Road might reach 50 to 55 dBA.

Standby Well Venting

Wells which have been drilled and capped are continuously vented through small bleed valves or through the exploratory shaft. Levels measured at 50 feet from these processes yielded 72 dBA and 80 dBA respectively. These levels are not considered significant.

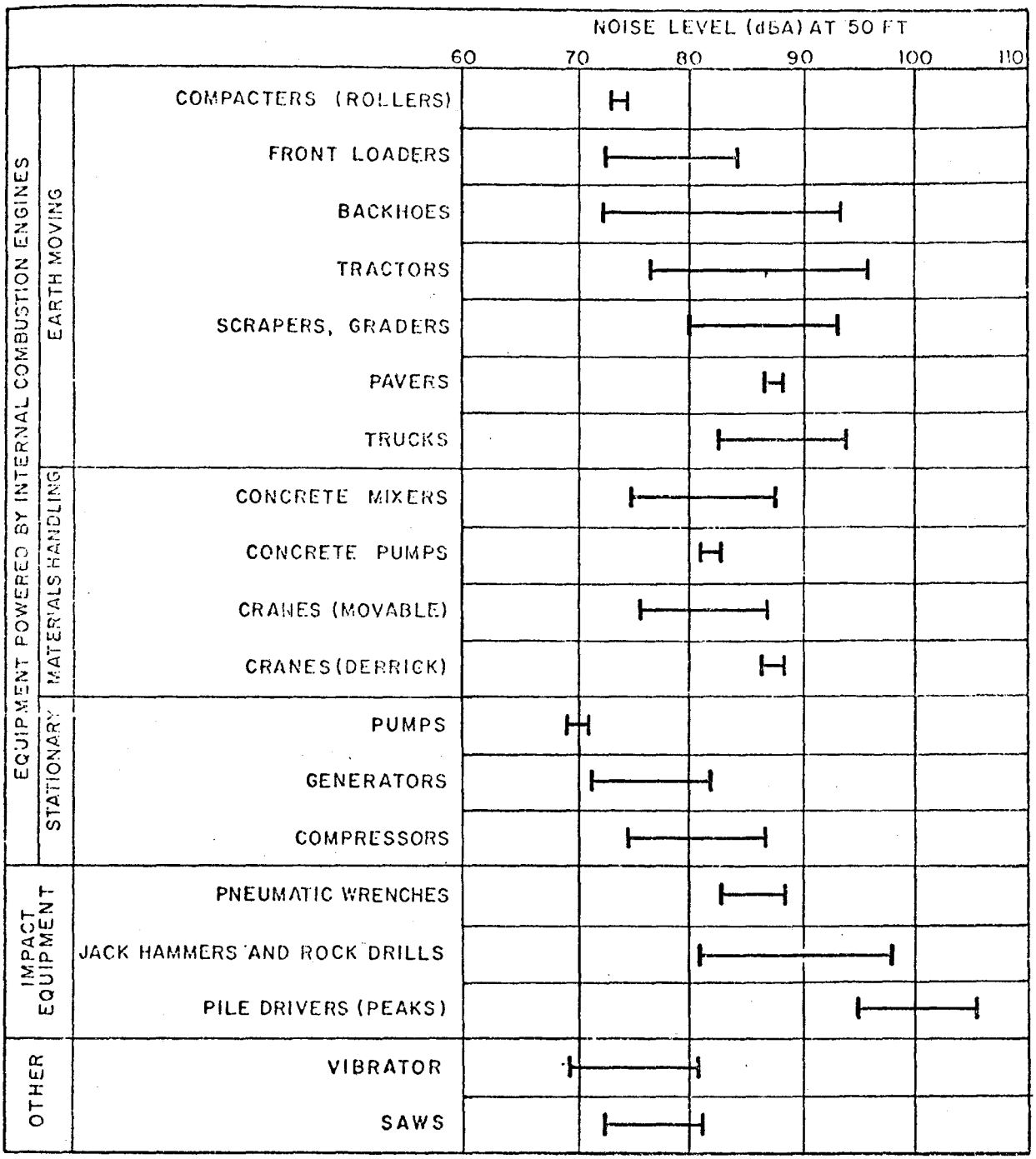
Pipeline Noise

High velocity flows through proposed pipelines will generate some noise. These levels have been estimated at 75 dBA at 50 feet with the insulating material lagging necessary to thermally isolate the piping in place. It is assumed that flow velocities in the pipes will be limited to 250 feet per second. This level of noise will not be a concern at the sensitive locations mentioned above. Venting of the well at the valve in order to prevent condensation in the pipes will cause higher noise levels than those given here and may be of some concern.

Some beneficial effects could come from the piping away of the steam if the need for periodic venting of the wells was reduced or eliminated.

CRITERIA, REGULATIONS AND ENFORCEMENT

Noise criteria has been developed to such a degree that certain limiting levels are accepted almost universally. The U. S. Environmental Protection Agency has suggested L_{dn} = 55 dbAas the appropriate noise level limit in residential areas and farms where people spend widely varying amounts of time and other places where quiet is the basis for use. The L_{dn} system uses the familiar A-weighting network, a system of energy averaging a 10 dBA nighttime penalty. Thus nighttime levels are limited to a 45 dBA energy average level in this system. Indoor noise levels consistent with a minimum of interference or annoyance have been set at L_{dn} = 45 dBA, or an energy average of 35 dBA at night.



Note: Based on Limited Available Data Samples

CONSTRUCTION EQUIPMENT NOISE RANGES.

FIGURE 14

The Federal noise criteria cited in the Federal EIS for geothermal steam wells is in basic agreement with these levels. This criteria reads as follows:

Specific Noise Criteria

Noise levels from any geothermal related activity shall not exceed the following industrial noise criteria at the lease boundary line. In addition, noise emitted from any geothermal related activity shall not result in increased noise levels exceeding the following use zone criteria as measured on adjacent properties at the closest point of habituation or use to the geothermal lease line:

Industrial and Geothermal Use	
Daytime	70 dB(A)
Evening	65 dB(A)
Night	60 dB(A)
Business and Commercial Use	
Daytime	65 dB(A)
Evening	60 dB(A)
Night	50 dB(A)
Residential - Urban	
Daytime	60 dB(A)
Evening	55 dB(A)
Night	45 dB(A)
Residential - Suburban	
Daytime	50 dB(A)
Evening	45 dB(A)
Night	35 dB(A)
Residential - Rural	
Daytime	45 dB(A)
Evening	40 dB(A)
Night	35 dB(A)
Agricultural	
Daytime	70 dB(A)
Evening	65 dB(A)
Night	55 dB(A)
Recreation	
Daytime	45 dB(A)
Evening	40 dB(A)
Night	30 dB(A)

Uninhabited or Rangelands	
Daytime	70 dB(A)
Evening	65 dB(A)
Night	60 dB(A)

The above noise criteria may be exceeded under emergency conditions upon approval of the Supervisor. Noise criteria may also be exceeded if the lessee obtains written permission from all parties affected by the noise which exceeds the above criteria. Complaints from persons to noise levels which exceed the above criteria in excess of 10 percent of the adjacent occupants to the geothermal lease shall cause the Supervisor to review the criteria as established and alter such criteria if, in his estimation, such levels should be reduced. The geothermal lessee shall be responsible for taking all measurements in the presence of the Supervisor or his duly authorized representative.

Assessment of Noise

In order to assess with respect to the expected objectionability, the rating sound level as obtained will be compared with the criterion value after adjustment for zone and time of day. If the rating sound level exceeds the criterion value by 5 db(A) the noise is considered objectionable.

Local Lake County Codes concerning noise are unfortunately highly inconsistent and show a general lack of uniformity and understanding of the noise phenomena involved. Section 21-73.4 of the Lake County Code deals with sound and is shown below:

73.4 Sound:

(a) The sound pressure level shall be measured with a Sound Level Meter and associated Octave Band Analyzer, conforming to standards prescribed by the United States of America Standards Institute criteria relating to noise and sound measurements. Measurements shall be made using the flat or "C" network, using the unweighted octave band sound pressure levels. (Ord. No. 645. 6.5.1, 1971)

(b) Table 1

Octave Band Frequency (Cycles/Second)	Maximum Permitted Sound Levels (In Decibels) Commercial and Limited Industrial	Heavy Industrial
20- 75	79	81
75- 150	74	76
150- 300	66	72
300- 600	59	67

600-1200	53	63
1200-2400	47	57
2400-4800	41	51
4800-9600	39	49

(c) If the noise is not smooth and continuous, and is not radiated between the hours of 10:00 p.m. and 7:00 a.m., one or more of the conditions in Table II shall be applied to the octave band levels given in Table I.

(d) Table II

Type of Location of Operation or Character of Noise	Correction in Decibels
(1) Daytime operation only	Plus 5
(2) Noise source operate less than:	
(a) 20% of any one-hour period	Plus 5
(b) 5% of any one-hour period (Apply one of these corrections only)	Plus 10
(c) Noise of impulse character such as hammering	Minus 5
(d) Noise of periodic character such as hammering or screeching	Minus 5

73.6 Geothermal Operations

(a) All geothermal operations shall comply with the following minimum standards:

.
.

(4) That drilling cleanout and well testing and producing operations be muffled at all times except in times of extreme emergency. There will be no changing of valves except on Monday through Saturday between the hours of 8 a.m. and 6 p.m.

(5) That the maximum permitted sound level shall be 80 decibels at a distance of one-half mile using "A" scale and measured with a Sound Level Meter and associated Octave Band Analyzer, conforming to the standards perscribed by the United States of America Standards Institute criteria relating to noise and sound measurements.

Several confusing and contradictory items appear here. The octave band frequency bands shown in Table 1 are not the standard recognized frequency bands which appear on most meters. Thus, it would be extremely difficult to find an instrument capable of measuring the levels specified. The octave band levels given as the limit in industrial areas converted to A-weighted level yield 60 dBA and those in heavy industrial areas yield 67.8 dBA. This is not an unreasonable limit. However, the specific limit put on noise from geothermal operations is 80 dBA at one-half mile from the source. This is extremely high in comparison to the other standards mentioned. In addition, it specifies that this level be measured with a sound level meter and octave band analyzer, when an octave band analyzer is not capable of or needed in making the measurement.

The Conditions, Procedures and Performance Standards for Geothermal Regulation, County of Lake, prepared by Hahn, Wise and Associates, Inc. and adopted as policy by the Lake County Planning Commission April 13, 1972 also addresses noise:

STANDARDS

1. DRILLING STANDARDS

   A. County-Wide Drilling Standards

      .
      .
      .

      7. Noise - The maximum permitted sound level for both air and mud drilling shall be 65 decibels at a distance of one-half mile from the drill site using the "A" scale and measured as set out on Page 1, Paragraph 7.

      .
      .
      .

   B. Restricted Areas - Drilling Standards (These are in addition to the county-wide standards and the County Planning Commission shall determine if a site is in a restricted area.)

.
.
.

7. Sound - The maximum permitted sound level for drilling shall be 50 decibels at a distance of 500 feet using the "A" scale and measured with a Sound Meter and associated octave band analyzer, conforming to standards prescribed by the United States of America Standards Institute Criteria relating to noise and sound measurements.

Again there is some confusion about the purpose of octave band analyzers, however the main difficulty here is that only drilling activities are covered by this regulation, not the venting and testing which occur after the well has been drilled and which represent the loudest source of noise in the area. The regulation stipulating that noise levels be reduced to 50 dBA at 500 feet would be very difficult in the case of geothermal steam operations.

Noise regulations are attached to use permits which are issued for a specific period, generally one to two years. The Lake County Planning Commission Resolution No. 74-105, issued on 9/20/74 is the use permit for drilling on the Davies Estate. This use permit is considered typical of that which would be issued for operations on the present project. Its noise sections are as follows:

1. TO PROTECT AGAINST EXCESSIVE NOISE EXPOSURE:

    1. Applicant shall not locate a drilling site within two-thousand-six-hundred-forty feet (2,640' - one-half (1/2) mile) of the community of Anderson Springs unless there is a demonstrated ability to attenuate sound transmissions to not more than 50 dB(A) during the loudest operational phase as monitored at any dwelling in said community.

    2. The maximum permitted sound level during any phase of the operation shall not exceed 65 db(A) at a distance of one-half (1/2) mile from the drill site.

    3. It is anticipated that the Lake County Air Pollution Control District will be spot monitoring noise levels in the vicinity of the proposed use and that findings resulting from said monitoring may require the applicant, his contractors, or agents, to provide continuous noise level monitorings and readings as may be directed by the Lake County Air Pollution Control District.

The noise levels here are in general agreement with those required by the Federal criteria mentioned previously. Anderson Springs is singled out as a sensitive location which indeed it is. Camp Verdant Vales is also a sensitive location although as far as the Davies site is concerned Anderson Springs is more critical due to its proximity. The Lake County Air Pollution Control District (APCD) is designated as the regulating body by planning policy permit only. Presumably the punishment would be the revocation of the use permit. If this in fact did occur it would produce considerable havoc in areas where there were inplace wells which were in need of periodic maintenance for safety considerations.

On Bureau of Land Management Land, there is no County Use Permit required and no agency to enforce the federal noise standards. The APCD has noted periodic violations of Lake County policy, (See letter in Appendix B) but is in a quandry as to what to do about them without direction from the County. The violations mentioned here occurred due to noise levels generated by the venting of McKinley 8 which is in the current project area.

In summary then, the noise level regulations in the Lake County Use Permits are generally in agreement with current federal regulations. Penalties for violating the conditions of the use permit would be the revocation of it. It is unlikely that this step would be taken on the basis of noise however. County Codes are contradictory and confusing. Federal codes are clear but have no enforcement mechanism.

In the absence of any mitigating measures, noise levels which have been established as limiting criteria for annoyance by the Environmental Protection Agency, the Department of the Interior Geothermal Drilling Standards and Lake County Use Permits will be periodically exceeded. The primary cause of these violations is the free venting of a well during testing, valve changes, blow outs and drilling. Violations due to operations on in place wells within the project area have been monitored both by residents of Anderson Springs and by Lake County APCD personnel. In view of the fact that the local ordinances forbidding 65 dBA at one-half (1/2) mile and 50 dBA in Anderson Springs are periodically exceeded due to similar activities to those proposed, the projected impact due to noise in Anderson Springs from the project is considered noteworthy and negative and in Verdant Vales is considered significant and negative.

Noise levels associated with truck traffic along Socrates Mine Road and the Ridge Road will increase due to increased construction activity. Noise levels due to truck and construction traffic are intermittent, occur only during the day and are not considered the potential source of annoyance that the venting is.

Piping of steam to a power plant could result in some alleviation of the free venting problem. The pipes themselves will emit relatively low levels of noise and are not considered significant. Venting and valve noise must, however, be controlled along the pipeline.

TERRESTRIAL BIOLOGY

PROJECT RELATED IMPACTS UPON FLORA

To date approximately 45 acres of vegetative cover have been removed by development within the project site. Future development will clear approximately 25 additional acres.

Erosion resulting from vegetative removal has caused additional impacts. Riparian vegetation has been disturbed by increased runoff and stream flow. Adjacent to the Socrates Mine Road, riparian vegetation has been covered by fill dirt from road widening associated with geothermal activity 250 yards upstream from the Thorne #5 padsite.

Additional vegetative disruption has occurred in areas where drainage culverts were improperly positioned causing gully erosion and the loss of further vegetative cover. This impact is present along the Socrates Mine Road below Thorne #5 padsite and below padsites CA 956 #1, McKinley #8, and McKinley #1.

On the south side of Murphy-McNeil-Lassiter Padsite, a rockslide has covered one-half acre of Chaparral. This impact is not as serious as a rockslide on the north side of the M.L.M. Pad site would have been, however, because Chaparral cover on the south side rather than Douglas-fir on the north slope was disturbed.

Some Knobcone pines have been killed by side effects of road and pad construction. Along the forestry ridge road, fill dirt has covered the base of several sensitive Knobcone pines, killing the trees. Although the mixed Conifer-Hardwood Association is not in a mature state of development, with the project site, it represents both a present and future asset in terms of land value. Commercial stumpage and recreational potential in the area are resource values directly affected by the level of maturity of the Mixed Conifer-hardwood forest. Aesthetic values are also enhanced by this community more than by any other. For these reasons, geothermal development should be minimized within this plant community.

The previous construction of several pad areas may cause additional vegetation damage to conifer forests this coming winter. Windfalls along the exposed edge of the forest near Thorne #3 pad site may occur from the sudden exposure of conifer species to winter storms with high winds.

Commercial forest species may also be cleared with future development. Logging plans should be coordinated with landowners to utilize this resource.

The fire hazard has also increased with the increase in local activity by man. This is a potential vegetation impact, and the fire hazard will

remain at a high level until development is completed. This danger is offset to a degree by the construction of roads, creating fuel breaks and providing access for firefighting.

Steam-Related Impacts Upon Flora

Much discussion has centered around potential vegetative damage from geothermal steam and steam-related emissions. Within the project area to date, impacts from steam-related emissions have not been discovered. Direct impacts on vegetation from the heat of the steam released during blooie-line venting procedures has occurred, however. Vegetative damage has been caused by steam scalding of the plants, and by steam condensate covering the leaf surfaces.

On the south edge of the Thorne 6 - McKinley 5 pad site, both riparian and chaparral species have been killed by steam released during blooie-line venting. This impact was unfortunate, since the blooie-line was later pointed in a safe direction and no vegetative damage occurred. A strip of vegetation 20 yards long and from 5 to 10 yards wide was killed by steam scalding, and from condensate covering leaf surfaces.

To the east of pad site CA 956 #1, Knobcone pines have also been severely affected by steam during blooie-line venting. Apparently, these trees are more sensitive to steam impacts than other species. Knobcone pines from 25 to 35 yards distant from the blooie-line were damaged, while the damaged vegetation near the Thorne #5 well was from 15 to 25 yards from the venting location.

A potential impact from the release of steam from wells, pipelines, and power plants may be an increase in humidity, associated with a decline in plant vigor and subsequent increases in plant disease. This assumption has not been confirmed to date, however. A research program is needed to determine if pathological or entomological problems present in local vegetation can be related to geothermal causes. Knobcone pine stands have been adversely affected near geothermal activities (impacts not due to steam scalding), but it is not clear what caused this condition. Some stands were one-half mile away, others from 100-300 feet distant. Forest vegetation is susceptible to a variety of pathological and entomological problems. Whether geothermal activities and increases in ambient humidity levels can be significantly correlated with local vegetation problems has not been established.

An additional potential impact upon flora is from the settling of steam condensate on vegetation and on the ground surface. Apart from the above-mentioned covering of the leaf surface and adverse impacts upon photosynthesis, a number of substances in the condensate are toxic to plant growth. Steam condensate settles on vegetation near

power plants. Boron, as tetraborate, is one of the most toxic substances in the steam condensate. The condensate contains up to 43 mg/L. of boron; for most plants 1-3 mg/L. is the toxic limit. Therefore, small quantities of condensate settling on leaf surfaces could damage plants. The effect of boron in soil water is more pronounced; condensate washed by rains into the soil could adversely affect vegetative growth. Vegetation attempting to re-establish cover on sites near geothermal development may be affected by condensate concentrating in soil layers. Again, this is a potential impact that requires further research.

PG & E has taken aerial infra-red color photographs of The Geysers area which show certain species near geothermal steam venting to be under an environmental stress. Species under stress have a "temperature," and appear in the infra-red photos. The vigor of these species is slightly abnormal. However, the entire vegetative cover within The Geysers area is under stress, due to the severe summer climate. The slight increase in temperature and humidity from geothermal steam may be critical enough to affect the condition of certain vegetative species already under stress. In perspective, however, the exact cause(s) of varying degrees of stress in vegetative species near geothermal areas has not been established.

Impacts Upon Flora From Non-Condensable Steam Emissions

Non-condensable gases in geothermal steam within the project area include Hydrogen, Methane, Ammonia, Nitrogen, Carbon Dioxide, and Hydrogen Sulfide. These gases are released into the atmosphere from air drilling, well clean-out and testing, bleeding shut - in wells, pipeline bleeding, generator by-pass, failure of transmission or generating systems, cooling tower discharges, blowout wells, and natural emissions from fumaroles and hot springs.

Of the above non-condensable gases, only Hydrogen Sulfide and Ammonia can be considered for potentially toxic influences upon the environment. Ammonia has been measured at or near non-detectable levels in several analyses of geothermal steam in The Geysers area, and does not represent a serious hazard to flora or fauna.

In an effort to determine ambient hydrogen sulfide concentrations and potential impacts, a program of hydrogen sulfide monitoring has been conducted in The Geysers area by PG&E, the Lake County APCD and the California State Air Resources Board. Burmah Oil and Gas Co. has also done monitoring of hydrogen sulfide within the project area.

In Anderson Springs, State A.R.B. Monitoring[137] from February to March of 1974 indicated no hourly averages of H_2S greater than .01 ppm, or below the limits of detectability.

In Middletown, H_2S was also below the limits of detectability, or below .01 ppm.

Within the project site, Burmah Oil conducted monitoring during August and October of 1974. The results were:[58]

County line-ridgetop:
August 21 9:30-10:30 a.m.: .003 ppm

Big Chief Mine (in a mine dump and a natural source of H_2S)
August 21 9:00-9:45 a.m.: .038 ppm
October 15 10:00-11:00 p.m.: .040 ppm
11:00-12:00 p.m.: .035 ppm

McKinley #2 well:
August 21 9:00-10:00 a.m.: .002 ppm
10:30-12:00 a.m.: .002 ppm

Anderson Springs
October 16 2:00-3:00 p.m.: Less than .01 ppm

Pacific Gas and Electric Co., in cooperation with the Lake County APCD has monitored H_2S near Power Plant Unit 11. This unit is located at a gap in the mountains where emissions from the Geysers area are carried eastward by prevailing ocean breezes. At Unit 11, the highest levels of H_2S were less than 2 ppm.[5]

The Lake County APCD has conducted monitoring at a location .4 miles north of Geyser Rock, on the Lake-Sonoma County line. 1.1 miles to the N.W. of this location is PG&E Unit 11, and .8 miles to the south is Unit 8. This monitoring was done during April and May of 1975. Again, this site is not in a collection basin, where concentrations of H_2S may be higher, but is in a common area for the flow of emissions eastward with wind currents from Sonoma to Lake County. In April, the highest hourly reading for H_2S was .380 ppm. The average for the month was .0478 ppm (On 23% of the days in April, the emission reading exceeded the state standard of .03 ppm, which is the odor threshold.)

In May, the highest average reading for H_2S was 93 ppb, at 2100 hours. The average was .024 ppm.[148]

The above figures describe current ambient levels of hydrogen sulfide within The Geysers area.

A review of the literature indicates that limited research has been conducted in the field of hydrogen sulfide impacts upon vegetation. Benedict and Breen[10] of the Stanford Research Institute, conducted fumigation studies on several plant species for four-hour periods, in

moist and dry soils. Concentrations of 100 ppm H_2S and 500 ppm H_2S were used. Hydrogen sulfide was found to be the only gas, among several air pollutants, to which younger plants were more sensitive than older. Also, plants growing in moist soils were more resistant to H_2S at 500 ppm concentrations than plants in dry soils. At lower concentrations, however, (100 ppm) plants growing in dry soils were more resistant to hydrogen sulfide damage than those in moist soils. A possible conclusion from this study is that plants growing in drought conditions (such as found in The Geysers area) would have a higher resistance to lower concentrations of hydrogen sulfide than plants growing in moist soils.

A study in 1970 in Los Angeles[62] showed that H_2S had limiting effects on the photosynthesizing cells of some plant species. Again, studies were only for several hours and with concentrations of H_2S above 50 ppm.

Ford, in 1973,[54] found that a molecular concentration of hydrogen sulfide of 2.8 ppm in upper soil layers for 5 days was the toxicity threshold for significant root injury to citrus trees. A higher concentration of sulfides than the 2.8 ppm concentration was also present in the roots that died.

In contributions from the Boyce Thompson Institute, McCallan, Hartzell and Wilcoxon[108] studied the effect of H_2S on 29 different species of plants. Similar to Benedict and Breen, they found that young, rapidly elongating tissue is more sensitive to H_2S than older tissue. This supports the results of the Los Angeles study in which areas of rapid photosynthesis were affected by H_2S. Typical symptoms were a scorching of the young shoots and leaves and marginal scorching of older leaves. Different species varied in their response. H_2S injury increased markedly with temperature increases, and wilted plants appeared less sensitive to injury than normal, turgid plants. At 20-40 ppm several species were slightly affected by fumigation after several hours. At 40-50 ppm, slight to severe injury occurred, depending upon the species. Tomato, clover and radish showed moderate injury at 40-50 ppm. Some species were not affected at concentrations above 200 ppm. However, as the temperature increased from 76 degrees F. to 90 degrees F., highly-resistant species at 76 degrees and 200 p.p.m. H_2S concentrations were slightly affected by only a 72 ppm concentration of H_2S.

Stern [140] suggests a concentration of only 1.5 ppm of H_2S by volume for a period of one-half to one day as the toxic limit for most plants. Brandt and Heck[16] discuss the dramatic tissue collapse of leaves during fumigation with high concentrations of the gas.

All of the above studies were conducted, however, over short time periods and with hydrogen sulfide concentrations above present levels detected by monitoring in The Geysers area.

The possibility exists that some species, although perhaps not directly affected by present levels of H_2S in The Geysers area, may concentrate sulfur from hydrogen sulfide and its reaction products in plant tissues to cause injury. The Ford study indicated that citrus trees concentrated H_2S in root tissue through their semi-permeable root membranes. The concentration of H_2S was also higher than in surrounding soil layers.

Erismann[51] found in 1968 that sulfate concentrations in leaves increased during favorable periods of photosynthesis. Leaves exposed to hydrogen sulfide were involved in intensive synthesis and concentration of sulfur compounds in their tissue structure. This synthesis occurred primarily in young, green portions of the leaves, where photosynthesis rates were high, and during favorable photosynthesis periods. One reaction that occurred was the oxidation of sulfide to sulfate.

The above findings by Erismann could explain the greater degree of injury to young, rapidly elongating tissue found by McCallan, Hartzell, and Wilcoxon, where photosynthesis was proceeding at a rapid rate.

Carlson[78] observed considerable injury to Douglas-fir near a pulp and paper mill in western Montana, and attributed the effects to SO_2 emissions. However, the measured levels and duration of SO_2 exposure are too low to have caused the pronounced effects. The H_2S emissions were not considered. Later work at this location[1] showed a maximum concentration of H_2S of .294 ppm at a distance of 215 miles from the paper mill. While SO_2 was only .049 ppm sulfur accumulated in conifer needles and showed a direct correlation with distance from the mill and prevailing wind vectors. Thus, H_2S is strongly suspected as the cause of injury but, because of a lack of well-controlled studies relating time-concentration exposures to plant responses, no conclusions can be made.

The above experimentation has shown that little injury has occurred over short time periods to sensitive plants with concentrations of H_2S of under 40 ppm. It is well known, however, that synergistic reactions between different pollutants may result in damage to vegetation at threshold levels lower than that of individual pollutants. It is possible that the damage to conifers near the pulp mill could be the result of H_2S, SO_2, and other emissions acting synergistically together.

The Montana work of Carlson and Anderson suggests strongly that H_2S is absorbed by plants and accumulates to cause injury. The results of sulfur concentrating in plants could cause injury similar to pathological conditions. Careful comparisons would have to be made with plants grown under the same general environmental conditions, but without the pollutant and in a disease-free environment.

According to the above research, the present levels of H_2S monitored in The Geysers area to date do not indicate concentration levels associated with plant damage. However, plant damage from the accumulation of sulfur in plant tissues, or from other emissions acting synergistically with H_2S to cause damage, is possible. One problem could occur if H_2S is transported to agricultural areas and during travel is oxidized to SO_2. If ozone levels exceed the state standard (0.10 ppm), [136] ozone and SO_2 could act synergistically to cause greater vegetation damage together than if they acted separately. Concentrations of ozone have reached the .13 ppm level in Lake County at Hollister,[137] during the peak oxidant season from July through September.

Several reports of suspected sulfur-related forest diseases and other plant problems, including orchard diseases, have recently occurred in Lake County. A U.S. Forest Service conifer plantation[9] north of Clear Lake has declined in growth significantly over the past year. No insects or pathological problems were found at the site, yet sulfur odors were detected. However, no conclusive evidence to date has related this plantation problem to sulfur-caused damage.

An apricot orchard near Clear Lake was also found to have disease problems, and sulfur was suspected as a possible cause. Again, no conclusive evidence relating these problems to sulfur or H_2S has been presented. On High Valley Road north of Clear Lake, conifer damage that was thought to be sulfur-caused was actually caused by insects. (Field Checking done by the University of California.) In all of the above cases, possible concentrations of sulfur emissions by wind currents and/or by an inversion layer was thought to have caused the above vegetation damage. Again, no conclusive evidence to demonstrate this assumption has been found.

Impacts Upon Vegetation from Steam-Related Emissions.

It is evident that further research needs to be conducted to determine if present atmospheric levels of H_2S, or of its reaction products, are causing environmental injury to vegetation in The Geysers area. With continuing geothermal development, it will be important to determine the levels of H_2S that forest species and agricultural crops will tolerate.

Dr. C. Ray Thompson is presently conducting research at the Statewide Air Pollution Research Center at U.C. Riverside, to determine threshold toxicity limits of H_2S on several vegetative species native to The Geysers area. His preliminary data should be available in September of 1975. These studies are also using ambient H_2S levels

in The Geysers area over long periods of time, unlike previous research efforts, to determine possible H_2S effects upon vegetation. These studies are preferred over the short-term and high concentration studies previously done. Dr. Thompson's research should generate baseline data needed to determine the exact environmental effects, if any, that H_2S has on vegetative species at The Geysers and within the project area.

An additional study is being conducted by the Stanford Research Institute, and will be coordinated by PG&E. This research began in July of 1975, and will characterize the area of influence of hydrogen sulfide and related emissions originating from natural sources and from geothermal activities. This study will also attempt to define specific environmental impacts associated with H_2S and its related reaction products. Precipitation studies will also be conducted, to determine if hydrogen sulfide or other reaction products contribute to any "acid rain" conditions found in the area. In addition, hourly meteorological and hydrogen sulfide data will be monitored at several sites.

Hopefully, the above research efforts will precisely determine the impacts, if any, of hydrogen sulfide, and its reaction products, upon the environment.

Rare and Endangered Vascular Plants

Areas containing species of rare and endangered vascular plants should be avoided in future planning. A qualified botanist should examine proposed sites to determine if rare and endangered plant species grow in those locations. Not all of the plants that fall within this category are identifiable during the time of the year that the present firm study was undertaken. Appendix E lists the most likely species that could be found within the proposed project site. It is estimated that some Lupine areas have been destroyed by previous development within the project site.

PROJECT RELATED IMPACTS UPON FAUNA

Approximately 45 acres of wildlife habitat have been disturbed by development within the project area to date. An additional 25 acres of wildlife habitat will be disturbed by future development. Approximately 50 acres will be restored, or are presently being restored, to habitat conditions approximating those found previously.

The disturbance of food and habitat significantly affects fauna who depend upon one habitat type more than several habitat areas for survival. Several small mammals have been lost in certain locations where they depended exclusively on one habitat type for survival.

Sensitive species have been forced by previous development to leave sections of the project area. These may include predator species who

require a large territory to hunt in, free from disturbance by man. Mammals affected in this manner include Mountain lion, Black bear, Weasel, Bobcat, and Ringtail cat. (A discussion of impacts upon the Peregrine falcon, and endangered raptor species, is included in the Wildlife section, under Rare and Endangered Species.)

Other species will readily adapt to the intrusion of their habitat areas by man. The coyote, an intelligent predator, will stay in an area if shots are not heard. Quail populations have increased significantly following brush clearing and the planting of grass cover during revegetation efforts.

In grassland areas where roads pass through the habitat, little impact upon terrestrial fauna will occur. In dense Chaparral areas, brush clearing will have beneficial impacts. Openings in the brush here increase the browse "edge" for deer and other species, improve access, and produce larger quantities of palatable vegetative growth. Brush rabbits, quail, birds and deer will utilize openings in the brush for feeding areas adjacent to a cover habitat.

The overall loss of food and habitat will cause both direct and indirect reduction in local wildlife populations. Before development, most wildlife populations were at a level approaching the carrying capacity of the area. Impacts upon wildlife include forced migration, loss of food, disease, increased mortality, and heavier competition for remaining food. Eventually, most wildlife populations will reestablish themselves at slightly lower levels than those that existed before development. The number of individuals lost corresponds to the number which the area of disturbed habitat would have supported. This process has already occurred to a large extent in the project area where development has occurred.

In areas adjacent to the project area, increased pressure upon habitat areas will result from the migration of some species. Wildlife in this category include Black-tailed deer, predators such as Bobcat, Grey fox, and Mountain lion, reptiles including Common gopher snake and Pacific rattlesnake, raptor species, and porcupines.

Disturbance of deer habitat has been offset by the growth of young browse species in cleared areas, and by grasses planted during revegetation efforts. Browse species in the project area show moderate to heavy deer use, indicating that the deer food situation is not overly critical. If sufficient cover or food habitat areas were disturbed by continuing development, however, impact upon local deer populations would be significant. Deer are a species, however, that more readily adapt to encroachment by man. Deer have already utilized cleared sites for new corridor routes.

Riparian habitats have not been greatly disturbed to date by existing

development. This factor will assist remaining wildlife species to adjust to abrupt changes in vegetative cover. The limited area of riparian zones make this valuable wildlife habitat vulnerable to future development, however.

The effect of road construction within the project area may be to divide wildlife habitats into sections so small that some species will not be able to survive. Accidents associated with road traffic will also cause the loss of some individuals.

In terms of potential acute or chronic physiological impacts upon fauna from toxic substances in geothermal steam, little is presently known. Potential respiratory injury to fauna from steam-related emissions is an area for future research. It is known that concentrations of H_2S above 20 ppm cause detrimental impacts upon human respiratory tracts. Project area concentrations of H_2S are below 1 ppm, however, and present no known hazards to wildlife.

Little information also exists on potential impacts upon fauna from geothermal-related noise. Deer have been observed feeding 50 yards from Geysers Power Plant Units. The consensus, according to Fish and Game representatives, is that most wildlife species will initially avoid development noise, but will return to previous habitats when ambient noise levels stabilize at a uniform frequency level. This decibel stabilization gives wildlife an indication that the noise does not represent a potential threat. Limited information exists concerning noise thresholds required to produce avoidance of geothermal activities by various species. Within the project area, a doe and two young fawns were observed in a nesting site 20 yards from the Thorne #5 padsite where drilling had been completed, yet where truck traffic produced a high level of noise.

Wildlife produced sounds, important for social communication, breeding success, and danger signals, may also be interfered with by geothermal-related noise. Reproduction rates for some species may also be affected.

Dr. Phil Lietner, a Wildlife Biologist at St. Mary's College in Moraga, California, is presently conducting research to determine impacts upon fauna from geothermal-related noise. His study began in July 1975, and will continue for one year. This study is intended to determine geothermal-related noise frequencies that will (1) cause initial avoidance of development areas by certain species, (2) prevent certain species from re-inhabiting previous locations, and (3) allow initially dispersed species to return to previous habitats. Dr. Lietner will also determine if noise from geothermal sources produces damage to the auditory system of wildlife and which species show behaviorial avoidance of noise sources. Whether species diversity, population densities, or reproductive success of certain species is affected by geothermal-related noise will also be studied.

If necessary, following Dr. Lietner's research, additional mitigation measures to minimize noise impacts upon wildlife from geothermal sources should be recommended. In the interim, mufflers and other devices as described in the noise section, are recommended to minimize all potential noise impacts upon fauna.

Within the project area, pigeons have disappeared in the last three years. Geothermal-related noise may have interfered with band-tailed pigeon warning signals, or simply have caused these birds to avoid the area.

Some bird mortality will result from above-ground obstacles such as drilling structures and transmission lines. Special perching nests are recommended for transmission line towers, as previously developed by PG & E, to prevent electrocution losses of raptor species.

Habitat and wildlife corridor disturbance from pipeline construction should be minimal. Cattle have been observed grazing in areas where steam pipelines have been constructed, and have walked under these raised pipelines. Deer and other mammals are expected to do the same. Additional fauna impacts from pipelines, including heat effects, are not anticipated at this time.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

One archaeological site, designated Geysers 124, and four isolated archaeological specimens were discovered within the Lake County portion of the project site. Nothing of archaeological significance was found in the Sonoma County portion. The impact of geothermal development on the four isolated specimens would be inconsequential. However, any development on the archaeological site Geysers 124 would have a serious adverse impact as the site is a relatively fragile surface phenomenon.

SOCIO ECONOMICS

ECONOMIC IMPACT - THE PUBLIC SECTOR

Of all the potential economic effects of geothermal development, the most discussed, and the one which appears to be of greatest concern is that of the effects of the proposed project on local government itself.

At first glance, the negative aspects of geothermal development seem minimal. Special districts which include the Castle Rock Springs development have demonstrated no greater increase in expenditures or burden over time of services as a result of the proposed project. The changes in tax rates and expenditures for those special districts serving Tax Code Area 62.003 (the Burmah development area) are not distinguishable from other special districts which perform similar services elsewhere.

The local government functions which might be affected by the proposed project include the following:

Administrative Costs/Permit/Legal
Fire
Protection/Sheriff
Roads and Highways
Water
Natural Resources Land Use/Soil Conservation/
Land Reclamation

Application and Legal Costs of County

The greatest costs thus far to the county appear to be those associated with the administration of the application procedure of geothermal developments. The administrative costs associated with the permits to include the time and resources of the Planning Department and the county government in regulating and monitoring the development of the geothermal area have been considerable. Additional costs include those associated with the many legal expenses that the county has had to undergo to defend whatever action it chose to make concerning permit applications. The Board of Supervisors and the Planning Commission have devoted considerable time to these projects. Estimates of the application and legal expenses associated with geothermal developments range from twenty (20) to thirty (30) thousand dollars.

Fire

Increased activity in any rural wooded area cannot help but increase fire danger. Increased inspection of the Plant 13 of PG&E and the wells and pipe system are required. PG&E and Burmah have made arrangements to offset this additional expense by reimbursing the county for the additional fire inspector time associated with the project.

Protection/Sheriff

As previously stated, due to private land restriction, there is minimal tourist activity in the Anderson Creek area. The local landowners do not allow public access to their land. Since there will be little tourist activity directly affected by the Burmah development, one might assume that there would be little effect upon the requirements for public protection.

Roads and Maintenance of Streets

Increased vehicle activity during the construction and the maintenance period of the geothermal development will result in increased use of county roads. When considering, however, there were, as of 1970, 12,954 autos, 4,624 trucks, 8,206 trailers and 883 cycles for a total of 26,685 vehicles in Lake County, additional road maintenance resulting from additional truck miles traveled over county roads as a result of the geothermal development should be of a minor nature. Of the 1,456 miles of road in the county, 653 are national, 133 are state, 634 are financed and maintained by the county and 25 miles of road are maintained by the City of Lakeport. The impact on roads as a result of development and maintenance of the Burmah Oil development and Plant 13 of PG & E would seem minimal.

Water

Presently Burmah Oil and Gas Company purchases water from private sources within the area. The county public water supply is unaffected. The County of Lake is presently undertaking a study of the present and future water requirements for the entire county.

Other Environmental Considerations

The long-run costs associated with the proposed project relating to redevelopment, land reclamation, and soil conservation are as of yet unknown. It is not determinable what burdens might remain

upon county government as a result of the environmental conditions existing after the steam runs out and the plants are abandoned. The estimated time and life of the geothermal plant development is 30 to 35 years. After 30 to 35 years of operation, the increase in sediment in the well site area may be significant and may require additional county services expenditures. (This potential cost is of concern to the Sonoma County Planning Department.)

In conclusion, the estimate of the burden on local governmental services as a result of the geothermal development appears to be minimal. The major expenses are those associated with administering and monitoring the permit application itself and providing for the legal costs associated with defending the county's decisions on permit application procedure.

Of special concern to local government (county, school districts and special districts) is the effect of the geothermal development upon assessed valuation and resulting property taxes resulting from the development in the Castle Rock Springs area. Modification of the tax revenue base and increased taxes were considered to be among the most important factors by those polled in the public opinion surveys.

The Castle Rock Springs geothermal unit is to begin operation (according to current scheduling) by June of 1978 and is to consist of a set of geothermal wells and a PG & E power plant with a capacity of approximately 135 megawatts.

The method used by the assessors in Sonoma as well as Lake County to determine the assessed evaluation of the utility and wells is that of the income method. That is an income stream (income paid for the steam) for a set of wells is estimated for the life of the wells. This future income is calculated by estimating the difference between the costs of the wells and the sales price of the electricity generated as a result of the steam coming from the wells. Once this income stream is projected based on the production of the wells and the projected sales price of the energy sold, then the income is discounted to arrive at some present day value of the earnings and then that income figure is capitalized at some rate of interest. The interest rate used to capitalize the income of the wells is based on the market rate with adjustments made for risk and other variables. Once the wells are in operation and are producing electrical energy, there is some reduction in the risk element, the capitalization interest rate is lowered, and a resulting higher valuation is allowed.

The assessed value (25% of market value) of the Burmah Oil development for the current fiscal year for the steam rights is $1,939,000. Add the assessed valuation for the improvements $96,500, and a total assessed valuation for the Burmah development for the current year is therefore $2,034,500. At a tax rate of $6.64 per hundred, the taxes levied as a result of the Burmah development this year was $135,908.80. It is

difficult to determine future property tax levies.

Future estimations of assessed valuation of the geothermal steam itself is speculative. The price of energy as sold by the plant, the amount of pressure in the wells, the production of the plant -- all will be factors determining the income and the assessed valuation of the geothermal steam area. Rough estimates would allow a calculation of a yearly tax revenue from steam or approximately $150,000 to $200,000 for the 30-year life of the wells.

A general rule by which property taxes are estimated is that a geothermal plant will provide approximately $2,500 of additional property taxes for each megawatt of power production. Utilizing this general rough estimate calculation, Plant 13 to include Burmah Wells, as well as the PG&E Plant, would provide approximately $337,500 per year in property taxes. (135 MW produced times $2,500)

This additional property tax revenue of $150,000 to $200,000 (from that of steam alone) could be used for other Lake County developments. As stated on page 103 of the Lake County General Plan, 1967:

> The most comprehensive plan is of little value unless it can be put to work. Lake County does not have enough income or tax base to construct all of the recreational facilities which would be desirable or needed.

Park and recreation facilities which would enhance the Lake County park system and which would enhance the recreational industry could, in part, be financed by the additional revenues received from the Burmah Development.

Lake County can become more competitive with other recreation areas if it can enhance its existing recreational facilities. Increased property tax revenues would allow public investments of this nature.

ECONOMIC IMPACT - THE PRIVATE SECTOR

As with many of the elements, it is difficult to estimate the effect of the Burmah Oil Development on the private sector of the economy. There has been and will continue to be an increase in local commercial activity as a result of this development.

Tourism

The unsightliness of the development may well inhibit tourist activity. Yet, the novelty of a geothermal development may well (during the first few years) encourage tourists to visit the area to see its development. In fact, a tourist or visitor center established by PG&E and Burmah Oil

could well generate tourist activity.

The existence of the plant may well inhibit some visitors from coming to the area and may result in reducing tourist activity. However, considering that much of the land in the area is private and is inaccessible to most persons, the effects of the development in deterring private parties from visiting the area would seem to be minimal.

Agriculture, Fish and Game, Timbering

Again, such effects seem minor and difficult to determine. Most of the area around Anderson Springs is open space (limited recreation) and as such would seem unaffected by steam development. Agricultural land use exists in the vicinity, but the distance from the project site (approximately five miles) suggests that the potential for harmful effects on cash agricultural crops is remote.

There are potentially harmful effects which would result from blow-out of the wells. Accidents of this nature would increase the toxic levels of the streams and the air and could result in harm to local agricultural products. Runoff as a result of toxic properties in streams could also affect water quality and could indirectly affect agriculture and forestry in the area. (See the Biology Section of this report.)

Not all of the purchases and manpower for the development of the geothermal wells by Burmah Oil is procured from outside Lake County. There appear to be substantial short-term and long-term economic inflows as a result of the Burmah Development.

There is local purchasing at the present time of some supplies, surveying works, pipe, steel, and lumber. Most purchasing takes place in Middletown, Lakeport and Lower Lake. Also, there are some local contracts awarded for construction and development.

There is a large payroll associated with the continuing development and resulting operation of the geothermal wells.

Anticipated Employment Schedule for Burmah's Geothermal Operations

1975	Men Employed	Quarter Payroll (000)
1st quarter	56	165
2nd quarter	70	231
3rd quarter	90	291
4th quarter	58	177

1976	Men Employed	Quarter Payroll (000)
1st quarter	59	180
2nd quarter	82	300
3rd quarter	102	360
4th quarter	65	216
1977		
1st quarter	59	180
2nd quarter	87	327
3rd quarter	107	387
4th quarter	72	249
1978		
1st quarter	50	153
2nd quarter	55	207
3rd quarter	45	163
4th quarter	40	138
1979		
1st quarter	30	92
2nd quarter	25	95
3rd quarter	20	73
4th quarter	20	69

The full-time employee schedule and the payroll figures suggest that the construction phase is to last through 1978 when the size of the payroll will contract as the Burmah Oil Development becomes operational.

Burmah admits that most positions will be filled by non-local persons. It is estimated, however, that approximately one-third of the employees will be locally hired. Also, the permanent well maintenance crew will be residing locally.

Given the size of the payroll, the amount of extra commerce and trade generated will be significant. One standard multiplier by which one can calculate the effect of an increased base payroll on the local economy is 2.5. That is, every additional dollar of base industry increased in the local economy will generate an additional 2.5 dollars sales on commerce. The Burmah payroll as projected will generate from two to three million dollars additional commercial activity per year for 1975, 1976 and 1977, and will generate approximately 750,000 per year additional local sales thereafter.

SUMMARY OF ECONOMIC IMPACT

The economic impact resulting from the Burmah Development includes effects on both the public and private sectors of the economy.

The negative aspects applicable to the public sector include: (A) the increased burden on county government resulting from the administrative

and legal costs of the permit application and hearing procedure itself. (Estimated to be between $20,000 and $30,000), and (B) the potential costs, yet unspecified, which would involve land reclamation, after the geothermal development is no longer operative.

The negative aspects applicable to the private sector include potential loss of recreational activity due to the existence of the Burmah Development. There is no estimate, but the amount is considered to be minimal. There might be some positive recreational effects as a result of the development as well. There is also some potential risk of harm to some crops in the area as a result of a steam blowout. The risk and harm are also considered minimal and there is no applicable dollar figure.

The positive public aspects include increased property taxes available for local government amounting to between $150,000 to $200,000 for the steam wells and approximately $375,000 for the plant. There would be additional revenues available for the county to develop recreational facilities which would assist the county in increasing its economic base.

There would be an additional private economic base which would provide additional expenditures and an increase payroll, resulting in a multiplier effect of from 2 to 3 million per year for the next two years and which would continue at approximately 3/4 of a million per year. This additional base support would help stabilize the economy and would reduce unemployment fluctuations.

VISUAL

The visual impact associated with the proposed project will be minimal. The project site is not visible from Highway 175. However, it can be seen from a few dwellings in the northwest section of Anderson Springs and from the dwellings adjacent to Socrates Mine Road. Cut and fill banks for pad sites and roads will increase erosion rates, creating a visual impact. This impact will be minimized by limiting cut and fill operations and using proper grading techniques and prompt revegetation procedures. Visual impact from plumes will be eliminated once the field is producing steam. The impact associated with the pipelines will be the only lasting impact. This will be minimized by the growth of vegetation along their paths and the use of green colored pipes.

CIRCULATION

Vehicular trips generated by the project will be trips destined to the site from residential areas and industrial areas within Lake, Napa, and Sonoma counties. Trips that originate from the site will be destined to these same types of land use.

During the present phase of the project (well production), vehicular trips will consist of three (3) to five (5) truckloads per day, of workers. On occasion, very wide loads must be moved along Highway 175 and for a short period of time the traffic must be stopped to allow clear passage for these trucks. Approximately fifty (50) loads are required to move one drilling rig on to the site, but once on the site, it remains until the project is completed.

After the field is in operation, these trips will be greatly reduced. Only maintenance crews will be required to visit the site. On occasion, a drilling rig will have to be moved onto the site for new wells and redrilling old wells.

Based on studies of similar types of projects and the existing conditions of this project, the impact on traffic circulation will be minimal. This impact will be reduced once the field is in operation.

OPEN SPACE SYSTEM AND RELATED PLANNING

The proposed project will remove a minimal amount of land from the open space system. This will consist of pad sites, roads and pipeline routes. The proximate location of the proposed project to the town of Anderson Springs will have effects on the residents. These effects and mitigation measures are discussed in other sections of the EIR.

MITIGATION MEASURES PROPOSED TO MINIMIZE THE IMPACT

INTRODUCTION

In general, several approaches to the project are being undertaken to minimize the impact on the environment.

- Comprehensive planning and coordination of all phases of the project including basic design parameters, access requirements, routing of pipelines, schedule of operations, testing, and maintenance. The total project is planned to minimize waste, materials, transportation and energy demands, disruption of the natural environment, and demands on consummable resources.

- Existing Regulations. Adherence to existing codes and standards will minimize impact in many areas of project activities. Conformance to relevant standards includes, but is not limited to, those promulgated by the following bodies:

  - Environmental Protection Agency
  - Regional Water Quality Control Board
  - California Division of Oil and Gas
  - California Department of Health
  - Air Pollution Control District
  - California Department of Fish and Game

- Monitoring Program. Air and water quality and noise levels will be monitored throughout the project duration. Critical operational parameters (e.g. pressure and temperature) will also be monitored in order to warn of catastrophic failure.

- Sound Engineering Practices. The best available technological practices are incorporated in all project designs. Structural designs, drilling techniques, equipment, and process will be selected to maximize efficiency, safety and environmental protection while minimizing waste.

In specific, mitigation measures to eliminate or reduce erosion, surface water contamination, the possibility of equipment failure, the release of gaseous pollutants, dust, and noise are discussed in the following sections. Mitigation of other impacts is also discussed.

GEOLOGY

Mitigating measures are necessary in order to minimize the impact of the proposed actions on the geologic environment as well as to minimize the impact of the geologic environment on the proposed actions. Basic mitigation measures in relation to grading, erosion control and sumps are included in "Specification for Preparation of Drill Sites and Access Roads" by Hawke Engineers (see Appendix A). These measures will be carefully followed. Similar considerations should be employed in construction of distribution pipeline routes.

It should be noted that the Hawke Engineers "Specifications" are of a general nature and individual sites may require special attention and construction techniques. All proposed construction sites for wells, distribution pipelines, power plants and access roads will have a thorough, detailed investigation by a licensed civil engineer experienced in soil mechanics and foundation engineering and by a certified engineering geologist experienced in slope stability analysis. The engineer and geologist will certify the stability of the site prior to commencement of grading. Inspection of cut and fill operations during grading should be maintained by both the soils engineer and engineering geologist. All fill will be placed under the supervision of a licensed soils engineer and certified stable by said engineer. All cut slopes will be constructed following the recommendations of the soils engineer and engineering geologist and certified stable by these professionals.

- As slope failure involving a well site can have very adverse environmental effects, ample precautions shall be taken in their construction. Fill for well sites shall be keyed into competent bedrock certified by the soils engineer and/or engineering geologist as capable of safely supporting the fill. Subdrains will be provided under all fills placed in natural drainage courses and in other locations where seepage is evident.

- Grading will be performed primarily in the dry season.

- As it will apparently be necessary for some of the proposed pipelines to cross landslides and/or potentially unstable slopes, these pipelines should have appropriate shut-off valves strategically placed that can be quickly activated in the event of pipeline rupture. Pipelines placed across landslides or potentially unstable slopes shall be designed so as the foundation piers can tolerate some minimal movement of the foundation materials without rupturing the pipeline.

- Appropriate measuring devices will be placed at regular intervals and regularly monitored for movement wherever pipelines are placed on landslides or potentially unstable slopes.

- Wherever feasible, pipelines will be placed adjacent to or on roadways to minimze additional grading.

- All facilities will be designed to resist anticipated seismic shaking and effects without failure.

- All drill sites shall be inspected and approved by an engineering geologist with the California Division of Oil and Gas.

- All grading in Lake County will be inspected and approved by the Lake County Director of Public Works, his authorized agent or the Lake County Environmental Control Officer.

HYDROLOGY AND WATER SUPPLY

- Enforcement of Existing Regulations. Adequate measures exist in present standards to prevent contamination of surface streams. Standards also exist to control discharge of wastes from drilling operations. Therefore mitigation consists of strict adherence of these standards as maintained by the Regional Water Quality Control Board, the Environmental Protection Agency and Lake County.

- Monitoring Streams. Intermittent streams emanating from slopes just east of Wardlow Rock will be monitored for water quality and turbidity when flowing. Burmah and cognizant public agencies will jointly share responsibility for setting up and maintaining adequacy of such a monitoring program.

- Placement of Access Roads Away From Streams. As far as is practical, access roads will not be allowed to cross or travel near streams. Careful routing of access roads will prevent sediment increase in streams and reduce chances of accidental discharge by drilling fluids or other contaminants into streams.

- Drilling Sump Design. A long term source of contamination will be rendered safe from the pollution-forming wastes in sumps by covering with an impermeable material such as concrete, soil cement or clay whenever possible. Surface compaction will also reduce surface permeability of the waste materials, and since it is by far the least expensive method of reducing permeability, it will be seriously evaluated for success of control.

- Revegetation of Disturbed Ground Areas. In terms of long range effects, proper revegetation of cleared out areas will eliminate excess runoff and reduce sediment discharge to streams with good probability of success.

WATER QUALITY AND AQUATIC BIOLOGY

- Care will be taken during the various phases of construction to minimize erosion. The extent of cleared areas will be minimized. The culverting of roads and prompt revegetation of cleared areas will occur.

- Care will be taken to minimize the release of geothermal fluids by preventive construction design, regular inspection of pipelines, and equipment.

- Direct impacts on water sources will be minimized by halting drilling operations, if stream levels become critical during low flow periods and not releasing effluents which would endanger the salmonoid fauna, especially during low flow periods.

- A basic monitoring program to assess effectiveness of mitigation measures will be conducted at the locations presented in Table 4:

  - Basic Water Quality: Take monthly measurements on Anderson Creek near the confluence with Putah Creek of the following:

    Temperature
    Turbidity
    Nitrate
    Sulfate
    Mercury
    pH

  - Steam Biota: Conduct one annual survey in April or May of stream major invertebrates (insects) and major vertebrates (especially trout).

  - Annual Water Quality Survey: Analysis of samples from six sites as in Basic Water Quality above, with the addition of the following:

    Chloride
    Sodium
    Potassium
    Florine
    Boron
    Alkalinity

- Erosion Survey: Conduct visual inspection of roads and construction sites for signs of excessive erosion during midwinter (January through February).

AIR QUALITY

- Increased vehicular dust on unpaved roads is a pollution problem but this will be minimized by frequent sprinkling during dry seasons. Without mitigation, the problem of dust is minimal. Dust caused by drilling will be controlled by adequate spraying.

- Another major impact occurs during power plant steam venting. It is important to reduce hydrogen sulfide (H_2S) emissions seventy five to eighty (75-80) percent from uncontrolled levels. Recent tests by PG & E demonstrated that abatement system using a catalyst removes ninety (90) percent of the H_2S from spent steam. However, corrosion problems occur, making this process costwise unacceptable. A novel feasible mitigation method must be found to reduce H_2S power plants emissions.

- In addition to removing H_2S from spent steam, the power plant should be built where the impact on the populated areas is minimal. To optimize the plant site, a meteorological monitoring program is necessary in the region. It would be helpful to institute tracer programs to delineate the impact areas of the various possible sites.

NOISE

- Codes

  - An effectively written Lake County Noise Ordinance, which is not tied to any particular phase of the drilling operation or sensitive location, with the penalties and enforcement procedure clearly stated.

  - Details from the U.S. Department of Interior on their noise criteria enforcement procedure.

  - Written permission from the owner(s) of Verdant Vales camp and school to locate wells within 1/2 mile, as required by Item 22 of the Lake County Conditions, Procedures and Performance Standards for Geothermal Regulation.

- Free Venting (See Appendix B for details)

  - An appropriately designed converging-diverging nozzle section could be installed ahead of the present diffuser to allow the diffuser to operate effectively. This could be quite effective, if it was determined that there was a shock bottle in the diffuser and thus Mach 1 flow near the exit.

  - A combination of an ejector or multiple ejector and shroud could also be utilized. If this type of sound attenuator were employed, the diffusing nozzle should not be used in order to decrease the size of the mixing region.

  - The use of an attenuating ditch could also prove effective. Flow would exit from existing pipes below grade level into a long ditch approximately 10' deep and 1' wide and perhaps 50' long. The natural attenuating properties of the soil would be utilized to quiet and slow the flow. The ditch should be covered over from the entrance point to approximately 20 pipe diameters downstream (or about 15' for a 10" pipe) with steel plate, concrete or other appropriate material. The remainder of the ditch should be covered with perforated screen for safety.

  - If one or more of the above methods proves more successful than the others, it should be utilized during the drilling phase, after steam has been encountered.

  - Free venting at the valve to prevent condensation in the pipes should be done through a muffler.

- General Considerations

  - In all cases venting should be done so as to direct the flow direction away from sensitive areas. In this case, a flow direction directly away from an area is superior to a vertical exit direction.

  - Where there is latitude in the choice of well locations, sites should be selected with a maximum of hills between the drill site and a sensitive location.

  - Avoid venting and testing on foggy days with a west or southwest wind.

- Mechanical Equipment

  - Mufflers should be installed and maintained on mechanical equipment. A limit of 90 dBA at 50 feet is recommended as an appropriate design criteria for mechanical equipment generated noise. Enclosures can also be utilized to attenuate noise levels where mufflers alone are insufficient.

TERRESTRIAL BIOLOGY

Mitigation measures to minimize project-related imp acts upon flora and fauna within the project area are essential. These measures include programs of wildlife management, fire prevention, mitigation of steam impacts, and revegetation. In addition, guidelines for the location of future development on the project site will be studied and implemented.

The following is a discussion of each mitigation measure related to terrestrial biological imp acts within the project area:

Revegetation and Erosion Control

Disruption of vegetative cover is one of the most critical single project impacts, causing both short-term and long-term effects. Erosion, visual scarring, and destruction of wildlife habitat are among the most obvious effects. It is therefore essential that the best possible programs of revegetation and erosion control be implemented within the project area.

Burmah Oil and Gas Co. has already initiated a program of revegetation, drainage design, and erosion control within the project area. On north-facing slopes, these measures have been successful on several sites in the re-establishment of vegetative cover and mitigation of impacts. On B L M lands, development has been fairly recent, and only along the Davies access road has revegetation been attempted. These efforts met with less success than revegetation efforts on the north side of the ridge, due to hot exposures and high serpentine influence south of the ridge. Burmah and the Bureau of Land Management are presently analyzing last year's revegetation program with a view to improving future efforts.

On north-facing slopes in the project area, soils are generally more fertile and moisture is more available than on BLM lands south of the ridgeline. The rock content of soils found on both exposures is still high, however, making revegetation efforts on either exposure difficult. Revegetation efforts on these slopes must occur in the fall, when rains add sufficient soil moisture to aid in the establishment of vegetative cover.

A seed mixture of Blando brome, Annual Ryegrass, Oats, and Burr clover was previously seeded onto cut and fill slopes adjacent to padsites and roads on north-facing exposures. Before seeding, the seed mixture was checked for thistle burrs, and other foreign contents. Monterey pine and Ponderosa pine were also planted around the edge of several pad sites and fill slopes, to retain topsoil and reduce scenic impacts. Hydromulching techniques, using spruce or other wood shavings, were not effective on most sites. The mulching of the seedbed with straw, however, was found to be more effective in retaining soil moisture, stabilizing slopes, and holding seed in place. Ryegrass was found, along with oats on some sites, to be the only species to grow well where hydromuchling techniques were used. On sites where straw or hay was used in mulching, however, Blando brome and some clover also came up well along with the rye and oats.

The seed mixture was hydroseeded, or applied in a water slurry, with fertilizer added. Fertilizer amounts were not in quantities that would burn the seed. Seeding was done in the fall of the year following development, prior to the rainy season. (The first fall rains are light rains, providing sufficient moisture for germination yet not disturbing the seedbed.)

Fertilizer was applied on three occasions. Fertilizers used had Nitrogen-Phosphorus-Potassium (N-P-K) ratios of 16-20-0, and 14-7-14. Seed amounts of 100 lb./acre were used. The 14-7-14 fertilizer, less potent than the 16-20-0, was initially applied with the seeds. After the first rains, fertilizers with 16-20-0 ratios, together with the 14-7-14 fertilizers, were applied to the seedbed. (The 16-20-0 fertilizer would have burned the seeds before the first rains.) Fertilizer was applied at 200 lb/acre and was also applied a third time, later in the fall, to aid the grass cover in establishing itself.

In a majority of the locations seeded in, the surviving grass cover was substantial. Since topsoil was more available on fill slopes than cut slopes, regeneration rates on the fill slopes were higher. Nevertheless, some cut and fill slopes in the project area experienced from 70-90% regeneration. Other slopes, including hot, dry exposures and some cut banks, experienced 30-50% regeneration. Overall, the majority of slopes reseeded experienced above 70% regeneration. A good grass cover was established on most slopes to hold topsoil and prevent erosion.

Some road and padsite areas north of the ridgeline, and on BLM lands south of the ridge, have not as yet been subjected to revegetation measures. These areas were developed this year (1975), and are scheduled for revegetation this coming fall.

To assist in the revegetation and erosion control program, tree species will also be planted on some locations in the project area, to minimize erosion and provide visual screening. An on-site nursery has been established for this purpose, and contains species of Douglas-fir, Ponderosa pine, Coulter pine, and the hardy Knobcone-Monterey cross. Each

of the above species may be utilized on different sites within the project area. Douglas-fir requires a good amount of available moisture, Ponderosa pine somewhat less available moisture, and the Coulter pine and Knobcone-Monterey cross minimal amounts of available moisture, to survive. Recommendations for the use of these species follow. This fall, an experiment with 50 of these seedlings is planned, to determine optimal planting sites for each species in the project area. In addition, several sites in the area may not support any of these woody species.

Seeding, fertilization, and planting are ineffective without proper drainage design and runoff control measures. Minimizing slope angles, road and padsite design, and the proper placement of drainage ditches and culverts are necessary to control runoff and erosion. Within the project area, revegetation and drainage-control measures have been largely successful in reducing erosion impacts.

GENERAL REVEGETATION MEASURES

- Revegetation to occur in the fall of the year in which development occurs.
- With re-entry into previously disturbed areas to lay transmission pipelines, newly disturbed areas should be reseeded.
- Scarification and reseeding of drilling pads should occur following all disturbance on the site.
- The proposed planting of 50 seedlings from the on-site nursery in several locations within the project area to determine optimal sites for each species is recommended for this fall.
- Setting seed in place prior to early fall rains increases chances for survival.
- Cut banks with little topsoil can be expected to yield marginal revegetation cover. Minimization of the size of cut slopes is recommended.
- In future development, minimization of vegetative disturbance is recommended. Padsites and road areas on BLM land are larger in some locations than necessary.
- Revegetation programs should be implemented this coming fall (Fall, 1975) on all sites disturbed to date where initial revegetation efforts have not occurred. This includes cut and fill banks adjacent to <u>all</u> roads and padsites cleared to date.

- Seed ratios previous ly used should be analyzed, in terms of results from different seed mixtures on various sites in the project area. A heavy weighting of Blando brome is recommended for seeding measures on north-facing slopes. Ryegrass and oats also do well on specific sites; in future seeding programs on adjacent sites or reseeding programs on these sites, rye and oats should also be increased in the seed mixture.

- Monterey pine and Ponderosa pine, or other site-adapted species, should continue to be planted around padsites and on some road fill banks. Staggered spacing of twelve (12) feet is recommended. Trees should be planted on slopes that will support growth without a program of additional maintenance; in addition not all slopes will support woody vegetation. On fill slopes adjacent to padsites, trees should be planted for a distance of 25 feet down the slope from the pad edge. Tree species will provide visual screening and hold topsoil.

- Topsoil should be stockpiled wherever possible for later respreading over disturbed areas prior to seeding.

- Erosion check dams should be constructed in drainage ditches which originate from padsites or roads, every 50 feet.

- Drainage culverts should extend into the edge of vegetative cover adjacent to padsites and roads, not stop 10 or 20 feet from the vegetation edge and cause gully erosion. Rocks should be placed under the end of all drainage culverts, to minimize erosion and further vegetative disturbance.

- On all cut and fill banks where the previous year's revegetation is sparse or has burned out, grass reseeding for the following fall should be planned.

- Seed should be purchased 6-9 months ahead of time and stored properly until used.

- Road and padsite engineering design should minimize disturbance of vegetative cover, reduce slope angles, and minimize erosion impacts.

- Oak-madrone slopes with loose shale surfaces may present problems. Direct establishment of woody species has shown limited success. A heavy stand of grasses should stabilize these slopes.

- Serpentine areas present special problems. Near Abel 1 padsite, woody vegetation establishment is not recommended. (See Appendix C).

- Seed species and seeding techniques should be adapted for each site. The variability in sites found in the project area, in terms of environmental conditions, requires special consideration for each site. A good rule to follow (where possible) is to attempt to re-establish vegetative species that grow on slopes adjacent to the disturbed site. In general, Blando brome, alta fescue, oats, annual ryegrass and palestine orchard grass will establish and survive in this area. Coarse aggregate soils such as loose shale should be broadcast seeded. Finer textured soils can be hydroseeded. Again, experience on fill slopes shows that punched straw is the most effective method of mulching, and of erosion control and slope stabilization.

It is recommended the the geothermal developers and Lake County jointly retain an individual to supervise and coordinate revegetation as well as erosion control programs in areas containing geothermal developments. A qualified agronomist, familiar with local vegetation, should be selected. This individual would oversee revegetation programs, and participate in research to develop cost-efficient and more productive revegetation and erosion control measures. This person would also perform wildlife habitat studies, search for rare and endangered vascular plants, and recommend revegetation species to be used on different sites. By coordinating these efforts, time and money will be saved in the long run through the development of efficient and economical revegetation and erosion control programs.

Cut and fill slopes along all access roads in the project area should be evaluated in terms of last year's revegetation efforts, and reseeded where the percent of survival was below 70%. The Socrates Mine Road near Anderson Creek requires reseeding on cut and fill slopes. This same road needs initial revegetation on cut and fill banks along its length from Thorne 5 padsite uphill to the conifer zone near Thorne 3. A drainage culvert on the Camp Verdant Vales road, 15 yards east of the Socrates road, needs two erosion check dams placed in the gully it has formed, and rocks placed under the end of the culvert to minimize further erosion. This slope also needs reseeding, and coulter pine planting is recommended for this area between the two roads where the erosion from the culvert has occurred.

Most cut and fill slopes along road areas north of the ridgeline need spot reseeding, where revegetation was first attempted last year. Other slopes need initial revegetation. Immediately most of the intersection of the Socrates and Verdant Vales roads, grass reseeding is needed on a steep slope directly adjacent to a sensitive riparian zone. Revegetation along the Forestry ridge road, before it crosses the ridgeline and drops down into BLM land, is in good condition.

Coulter pine or Monterey-Knobcone pine cross are also recommended for planting on the entire slope area adjacent to Socrates Mine Road from Thorne #5 Padsite uphill to the Thorne #3 access road.

Fauna

Vegetation disturbance and resulting habitat displacement should be minimized. Riparian area buffer zones also need to be preserved, as they are valuable to wildlife.

Previous mention has been given to mitigation measures for the Peregrine falcon, an endangered species, in the section on rare and endangered fauna.

- Areas where raptor nesting sites are known to be located should be avoided. This includes conifer stands adjacent to Thorne #3 Padsite, and to the west of the forestry ridge road (See wildlife distribution map). Wildlife corridors are also located on this map; roads and pad locations should avoid these corridors.

- Ecotones, or edge areas, should also be avoided. In these zones, a greater diversity of vegetative species exist, providing a wide variety of wildlife foods.

- Before grading permits are issued, it is recommended that the Department of Fish and Game check proposed development locations to insure that edge areas and critical wildlife habitat zones are avoided.

- Mufflers and other noise-reduction devices are recommended to minimize noise impacts upon fauna.

- To mitigate impacts from development upon deer habitat within the project area, Russian olive or other available deer browse species should be planted in riparian areas. Anderson Creek is recommended for this planting, for 300 feet above and below the Socrates Mine Road. Planting of these species is also recommended for five-100 foot sections along year-round streams near Camp Verdant Vales.

- Revegetation of disturbed sites will mitigate wildlife impacts significantly. After the completion of geothermal activity on the pads, these areas should also be scarified and re-vegetated with grass species to restore wildlife habitat. Habitat areas in over75% of the project area will be restored to conditions approximating those previously existing. In the interim period before habitat conditions are fully restored, plant foods will be provided for many species.

- Recommendations regarding preservation of a section of BLM land, together with adjacent areas of the use permit area, are included in the Department of Interior EIS discussion. This valuable habitat zone that should be preserved for wildlife use is north of the Davies access road, east of Wardlow Rock, and southeast of Camp

Verdant Vales. This zone contains Madrone-Oak, Chaparral, Mixed-Conifer hardwood and Knobcone pine communities. Wildlife use should be allowed to remain at a high level in this zone, since this is one of the only undeveloped sections within the project area. Development should not be recommended for this area (see vegetation map).

- Following well completion, toxic substances should be removed and the sump areas covered and revegetated.

Fire prevention

With the increase in human activity within the project area, the probability of fire has also increased. The buildup of vegetation, including mature Chaparral, has increased the chance for a crown fire to spread through the area. This fire would destroy, for the short-term, valuable vegetative cover and wildlife habitat in the project area.

- A fuel break at least 15 yards wide around each drilling pad and 10 yards wide along steam pipelines, should be cleared of brush but not of grass cover. This will reduce fuel structures and the high fire hazard.

- Workers in the area should be cautioned in the use of lighted material. A fuel break along the forestry ridge road has been constructed in the southwest corner of the project site. This road should act as a firebreak to control brush fires originating from the Big Sulphur Creek drainage. The Davies access road, along with other access roads throughout the project site, will aid in controlling the fire threat by providing fuel breaks and access for fire-fighting.

Steam Impacts

Impacts upon flora and fauna from steam vented during geothermal activities are largely unknown, and require further research. Adequate mitigation measures are in order, however, for blooie-line venting procedures where flora has been directly affected by steam scalding and damage from steam condensate covering leaf surfaces.

- A distance of at least 35 yards should be maintained from blooie-line venting, or other steam venting, and the nearest vegetation. In areas where this is not possible, the blooie-line should be

tilted upward at an angle, to minimize steam effects upon vegetation. (This would be subject to engineering limitations.) Blooie-line venting has caused direct plant damage near several drilling sites within the project area. Other steam venting activities to date in this area have been well-regulated, causing no direct vegetative damage.

Until further research defines the exact influence steam emissions have upon native flora and fauna, mitigation measures cannot be proposed for these potential impacts. PG&E is presently, however, conducting programs of H_2S abatement at its Geysers Power Plan Units, to meet California State Air Resources Board air quality standards. Should further research necessitate additional abatement programs, these would be recommended. PG&E presently uses an iron catalyst to precipitate sulfur, oxidizes H_2S to SO_2 and uses a burner-scrubber to clean off the SO_2, and utilizes off-gas ducting to minimize H_2S emissions. There are additional methods of H_2S abatement, including chemical absorbtion and adsorption, microbiological processes, soil filters,[29] and other techniques. The above measures would only be implemented if deemed necessary.

In addition to previously-mentioned research programs related to geothermal steam impacts, conducted by S.R.I. and by Dr. Thompson, the Lake County APCD is planning to set up test plots to document potential vegetation damage with time.

Most of the above research is related to steam impacts upon flora. An additional program of research to determine other possible impacts upon fauna from steam emissions may be required. It is suspected, however, that impacts upon fauna would be similar to impacts upon humans. Concentrations of above 15-20 ppm of H_2S are required to produce detrimental impacts upon human respiratory tracts. These concentration levels are not indicated by monitoring within the area. Thus, minimal impacts upon fauna from geothermal steam are anticipated. Only avoidance of the steam source by wildlife has been observed.

Future Development

- Future development of padsites and access roads should not be located on steep slopes. Development on these sites causes excessive vegetative disturbance, erosion, and visual scarring. Drilling sites having the least slope within the project area should be selected; drilling sites should not be located on slopes exceeding 30%.

- A buffer zone preventing development is recommended along riparian areas to protect these critical areas. Wildlife habitat, scenic value, and stream quality are all affected by the condition of riparian areas. This zone would be at least 150 yards wide, 75 yards in each direction from the stream.

- In the riparian zones adjacent to the Socrates Mine Road, above the Thorne 5 padsite, fill dirt from the road has been pushed into the creekbed. This practice is detrimental to riparian zones, and should be stopped. The construction and/or widening of roads along riparian areas should be limited. Road crossings are necessary, but constructing future access roads along riparian zones is not recommended. The above mentioned riparian buffer zones throughout the project area should also be maintained.

- Access roads should be constructed to minimize vegetative disturbance. Roads in some areas of the project site are extremely wide, especially in BLM territory. Careful thought should be given to the necessity of an access road before its construction. Cat trails should also not be punched through the woods for exploratory reasons; development should be planned well in advance to minimize the total amount of area disturbed. Near McKinley padsite #8, and McKinley #2, two access roads lead into these pads instead of one. This situation should be avoided, if possible.

- Padsite and drilling sump areas with BLM territory appear to be excessively large. Future development should minimize the site of padsite and sump areas.

- In areas where development is planned, the following order of vegetative communities should be used to determine drilling site and road locations. (avoiding steep slopes, wildlife corridors, and edge areas of ecotones is also recommended.)

    Rocky and barren areas
    Grassland, except in unstable areas
    Chamise Chaparral
    Manzanita-Buckbrush Chaparral
    Interior live oak-Manzanita-bay communities
    Knobcone pine and Cypress
    Madrone-Oak
    Mixed Conifer-hardwood
    Mixed Conifer

This order does not place a relative value on each community, but rather lists associations in a successional order. Plant communities toward the bottom of the list will require a longer period of time for ecological succession to re-establish them as a dominant cover type. Communities toward the bottom of the list also minimize erosion, build topsoil and humus layers, are aesthetically more pleasing, and commercially more valuable.

- To prevent soil movement and additional vegetative damage, care should be taken to avoid undercutting unstable soil masses. The placement of large fills should also be supervised to minimize erosion, while areas of soil creep should be avoided.

- PG&E is planning to fly infra-red and color photography over the areas of potential future development to determine thelocation of sensitive vegetation types. These areas will be classified in an order of sensitivity, with subsequent planning avoiding the more sensitive vegetational areas.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

No mitigation is recommended for any development that affects the find locations of the four isolated archaeological specimens. The reconnaissance itself, which resulted in the recording of the finds, can be considered as adequate mitigation. The specimens were collected and accessioned at the Anthropology Laboratory, California State College, Sonoma, where they are available for further study.

Mitigation of potential adverse effects of geothermal resources development upon archaeological site Geysers 124 is recommended, however. While Geysers 124 is a significant archaeological resource, it is not sufficiently important to warrant preservation by designing development so as to avoid the site. Such a move, however, would certainly avoid adverse effect to the site. The following procedures are recommended to mitigate damage to the site or destruction of the site, if geothermal development impinges upon its area.

- A two-phase program of mitigation should be initiated. The initial phase should be so designed as to provide material to allow fuller evaluation of the significance of the site with respect to the following variables: (a) horizontal extent of the site; (b) maximum depth of occurrence of archaeological materials; (c) time or times of prehistoric utilization of the site area; (d) nature of site utilization; (e) nature of materials and information that could reasonably be expected to be gained or recovered from the site, if additional investigation were carried out.

  The Phase II investigations should be designed on the basis of Phase I results so as to provide more extensive and detailed information. The Phase II work should be conducted according to standard archaeological techniques with special lines of investigation included when warranted by Phase I data. It is within the realm of possibility that Phase I investigations at archaeological site Geysers 124 would be sufficient to mitigate adverse effects of geothermal development.

- It is recommended that Phase I investigations satisfy the following scope of work: (a) the excavation of one to three standard excavation units with soil screened to at least six (6) mm mesh; wet screening should be conducted if at all possible; (b) systematic surface observations to obtain an adequate sample of surface archaeological specimens and to determine the horizontal spread of surface materials; (c) systematic coring of the site to determine depth of occurrence of archaeological materials in different portions of the site and to determine horizontal spread of buried materials; (d) collection of appropriate samples for age-dating and materials for source identification; (e) support should be provided for technical procedures (e.g., age-dating, source identification), laboratory analysis, and report preparation; (f) the Phase I report should recommend what the nature of Phase II investigations, if any, should be.

- Phase II investigations, if recommended, should enlarge upon the above scope of work and, in addition, be designed to deal with any special line of investigation warranted by the Phase I investigations. Recommendations for the specific Phase II investigations cannot be detailed on the basis of available data, but must await Phase I results.

VISUAL

- To reduce the visual impacts associated with transmission pipelines, green anodized pipe could be used and vegetative disturbance minimized.

- The removal of vegetation for pad sites and roads should be minimized.

- Revegetation should occur as soon as possible to minimize the visual impact associated with cut and fill banks.

Visual impacts will be severe if development occurs on the southeast slope across from Camp Verdant Vales. This slope should be part of a scenic viewshed for the area. If development must occur, revegetation should take place as soon as possible.

A fill slope in the eastern end of the Davies access road within the project area is visible from Anderson Creek. Grass revegetation measures, and the planting of conifer seedlings on this slope, is recommended for the fall of 1975. Monterey and Ponderosa pine planted around the Murphy-McNeil-Lassiter padsite are doing well, and reduce visual impacts to a degree. A number of conifer trees need to be planted

around padsites and on fill slopes adjacent to roads, where they will survive on their own and where visual impacts are significant. Detailed revegetation procedures are discussed in another section of this Environmental Impact Report (EIR).

CIRCULATION

- Heavy truck movement to and from the site will be restricted to non peak flow hours. This will minimize time and number of vehicles stopped by truck movement.

- Employees will be encouraged to carpool. Where possible, mini buses will be used to transport workers to and from the site.

ENERGY CONSERVATION

The proposed project is itself an attempt to harness an energy source, and the utilization of that energy can be considered to conserve other depletable fuels by providing an alternative source. The operations of drilling, transportation, construction and steam delivery may themselves be evaluated for efficiency of energy consumption.

- Drilling

  Drilling equipment is essentially standard petroleum hardware, and drilling practices are according to American Petroleum Institute standards. Direct diesel drive is used to provide rotary power to the drilling apparatus; this is the preferred configuration for best efficiency.

- Drilling support equipment

  Apparatus ancillary to drilling operations is powered by site generated electric energy. This permits portability and flexibility in operations.

- Transportation

  Since drilling operations are performed with a minimal crew, transportation of workers and equipment is effected with a minimum of vehicles. Approximately 10 passenger car trips per day are anticipated.

- Retention of steam

  Steam loss during drilling and testing is to be held to a minimum. Non-return valves and blow-out preventers are employed to protect against excessive loss of steam from the wells. Steam pipelines and wells are located away from landslide areas to reduce chances of rupture or blow-out and subsequent loss of geothermal fluids.

- Insulation

  Steam pipelines are insulated to minimize heat (energy) loss from the steam when in transport to the electric generating plant.

ALTERNATIVES TO THE PROPOSED ACTION

Alternative uses of this resource are of great interest to the people of Lake County and it is suggested that current investigations of these uses, as discussed below, continue.

ALTERNATIVE USES OF THE GEOTHERMAL RESOURCE

Section 6903 of the Public Resources Code of the State of California states that "...'geothermal resources' shall mean the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, and resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substances."

Alternative modes of exploiting the geothermal resource of the property are discussed below.

Using Natural Steam for On-site Processes

The use of natural steam itself for processes in factories, pulp or timber mills, food industries, etc., requires the delivery of a controllable and variable quality of steam. Viability of such processes depends on physical characteristics of the steam as well as the market for the process, commodity, or the service. There is a considerable quantity of steam in the geothermal resource area. Insufficient market exists locally to adequately utilize the resource.

Natural Steam Itself

The drilling process itself can be devoted to the extraction of steam for constituent chemicals. The heat of the steam would work against chemical treatment, although the pressure would facilitate the delivery of steam from underground. The use of steam for chemical extraction depends on the chemical content, the nature of the recovery process, and the market for the chemical products.

Condensate from Another Process

Chemicals may also be extracted from the condensate or residue from a concurrent process. Presumably the heat and pressure of the natural steam would not be sacrificed, and the extraction process could utilize

on-site power (mechanical or electrical) generation. Practicality of this extraction would also depend on the chemical content of the condensate or residue, the nature of the recovery process, and the market for the chemical products. Since the resource is relatively clean, no chemicals exist in sufficient quantities to make extraction economically practical.

Thermal Energy

- Desalination

Heat from the natural steam can be utilized in multi-stage flash distillation processes to produce potable water. Use of geothermal steam for this purpose requires a nearby source of water to be desalted in order to be practical. Other parameters to be considered include the temperature, pressure and cleanliness of the steam, as well as the marketability of the distilled water. In the project area, sufficient potable surface water supply exists to render this option impractical.

- Domestic Uses

Heat can also be used to meet the space conditioning and domestic hot water needs of communities located in the vicinity of the producing wells. The piping of steam (or some other medium bearing the heat) depends greatly on the proximity of the community (or, for example, a a resort or housing complex). The initial temperature of the steam is important, as is the ability to transport the heat without substantial heat loss. While feasible in the project area, the demand for such uses would constitute a considerable underuse of the resource.

Heat can also be used for such applications as greenhouses, low temperature industrial processes (salt baths, solution tanks), and food industry processes (drying). Again, proximity to final users is crucial to success. At present, insufficient market exists in the project area to render this alternative practical.

All of these alternatives involve questions of effect on the environment. On-site problems involve considerations of land use, access, erosion, traffic (cargo hauling), noise, waste elimination and growth inducement. The chemical extraction processes can involve large solar evaporation ponds and aesthetic problems. The use of geothermal heat for domestic heating purposes must be compatible with the community's plans for growth in the vicinity of the resource area.

ALTERNATIVE USES OF THE SITE

No Action

In the past, the project area has been used primarily for limited forestry, mining, agricultural and recreational activities. Lake County is noted for its orientation toward services for its inhabitants, mainly retirement or recreation based services. Although intensive in some parts of Lake County, agriculture is limited to rangeland or wildlife habitat purposes in the hill terrain of the project site. Recreation is confined to water related activities, and the major centers of activity are along streams and in Clear Lake, outside the project site. A "no action" posture would mean a continuation of these limited activities within the project site and a continued services-oriented retirement community in Anderson Springs. Forestry would continue on an intermittent basis. Coupled with reactivation of mining operations, required access roads would create environmental impacts such as erosion, pollution, traffic and noise.

Development of Recreation Activities

Recreation activities are focused around water in Lake County, particularly Clear Lake. Boating, swimming and fishing are popular sports. But, the project site contains few water resources suitable for recreation, and therefore, intensification of recreation would require development of other types of activity such as hiking, camping, sport or target shooting, etc. The major impacts would be requirement of access roads, installation and maintenance of water and toilet facilities, with the accompanying increase in noise and vehicular traffic.

Residential Development

Construction of houses in the subject area would require an economic analysis to determine market, tax base to support community services, and greatly increased access. Compared to the proposed project, this option would be energy consuming as opposed to energy generating, it would use greater acreage, and resources such as water supply would be irretrievably committed.

Agriculture

Development of agriculture would amount to a "no action" option in the study area. Forestry would proceed as the primary agricultural industry because the hilly terrain renders most other farming interests impractical. Logging has in the past been a major industry in this area. Resumption of logging activities will require an influx of labor to operate equipment, create frequent hauling traffic, and lead to greater increased erosion, noise, runoff, and other environmental effects.

Mining

Two Mercury mines have operated in the project area. Activation of these mines would necessitate an increase in labor, traffic, and surficial contamination. The current depressed market for mercury has thwarted intensification of mining; an increase in demand for mercury would stimulate resumption of mining.

ALTERNATIVE METHODS OF GENERATING ELECTRIC ENERGY

The ultimate theoretical capacity for generating electricity in the Castle Rock Springs geothermal development is 135 MW. This energy could be provided by other means, and the following paragraphs discuss alternative methods of generating electricity assuming development at the project site is halted. Each form of electric energy generation has its own set of environmental impacts, and these impacts will also be discussed.

Hydroelectric

Hydro projects require immense storage facilities and thus much valuable land must be inundated for that purpose. Other negative characteristics include: displacement of people, reduction of wildlife habitat, damage to stream fisheries, and elimination or disruption of free-flowing streams. Positive characteristics include the absence of polluting by-products, high efficiency of operation, increased dependable water supplies, recreational facilities, and reservoir fisheries. Cursory studies conducted by the Department of Water Resources indicate that dams along Putah Creek may provide 79 MW of electric generating capacity, and one site near Middletown would provide 17 MW capacity if developed.

Natural Gas

Natural gas is the cleanest of fossil fuels, but even it, when burned, produces carbon monoxide if combustion is not complete and nitrogen oxides. Waste heat is also generated in gas fired boilers and gas turbines, and this heat must be discharged to the atmosphere through cooling towers or to streams. Natural gas, however, is in short supply in California. Gas supplied in northern California is imported from Canada, and that country's government has acted recently to increase the price of natural gas to equal, in terms of energy equivalence, that of oil.

Oil

Oil accounts for the largest portion of fuel for generation of electricity in California. Increase in dependence on oil for electric generation has resulted primarily because of the decreasing availability of natural gas. Oil provides thermal energy in combustion, and environmental effects of oil burning include generation of nitrogen oxides, carbon monoxide, sulfur dioxide and particulate matter. Oil burning also creates heat in excess of that required for power generation and this must be abated. The worldwide fluctuations in the price of oil indicate the importance of this resource. However, American production is dropping off and dependence on foreign oil is increasing.

Coal

Coal is a resource the United States possesses in great abundance, although little abounds in California. Mining of coal, however, requires commitment of vast land use for strip mining and costly replacement of disrupted earth. Use of coal for fuel in electric generation involved adverse environmental effects on air quality (emissions) and water quality (emissions and thermal pollution). Most coal found in the United States contains considerable quantities of sulphur and damage from sulfurous by-products of combustion is a major hazard of coal burning. Coal is not mined in California and its use here would require import.

Oil Shale

Not currently available on a large scale basis, the high cost of energy from conventional sources has stimulated development of the vast acreage of oil-bearing shale in Colorado, Wyoming and Montana. California contains smaller deposits of oil shale near Santa Maria. Mining of oil shale and concurrent processing of oil is an environmentally costly procedure. Waste from processing plants is relatively inert (sterile), is produced in voluminous quantities, and requires energy and biological treatment to be restored to a vegetation supporting landscape. Large areas of land are disrupted in mining and considerable waste supply is required. Pollution of ground and surface waters is considered a leading environmental cost. Oil extracted from shale produces by-products of combustion as does "conventional" oil.

Solar Energy

Solar energy possesses potential for meeting energy needs in two ways: (1) Direct conversion of sunlight into electricity; and (2) Reduction of energy required for domestic heating (especially, of water). Costs of direct conversion units are still prohibitive and cannot be expected to contribute significantly to electricity supply in the immediate future. The second use is gaining widespread appeal (e.g., recent proposals for tax incentives for installation of solor heaters). Technology is available to implement solar heating facilities on a unit by unit basis, but here again no real reduction in energy demand is foreseen for several years. Environmentally, solar energy involves fewer impacts than conventional fossil energy sources except solar cells for direct conversion of sunlight to electricity require immense land (spatial) commitment.

ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED IF THE PROPOSAL IS IMPLEMENTED

Major unavoidable adverse environmental effects that would occur upon project implementation are:

- Increase in erosion, runoff and sedimentation
- Increase in noise
- Loss of vegetation
- Loss of habitat for wildlife sensitive to encroachment by human activity

Specific details of these and other adverse effects follow.

GEOLOGY

There will be a slight increase in runoff, erosion, and sedimentation as a result of grading.

HYDROLOGY AND WATER QUALITY

Some increase in stream sediment loading during the winter is unavoidable. The severity of impact will depend on the effectiveness of mitigation measures employed and on the extent of development and construction. An increase in undesirable chemical constitutents from steam condensate will also be likely.

Any withdrawal of surface water for drilling, human consumption, etc. could have a serious impact during summer periods of low flow on the native trout.

AIR QUALITY

The project will require the clearing and leveling of well site areas and the construction of access roads. As a result of these operations, there will be increased emissions from internal combustion engines used on the drilling equipment and for construction and from cars and trucks bringing in crews, equipment, and supplies. These increased emissions will be negligible in terms of an air pollution impact; however, this increased

vehicular traffic will increase dust levels particularly in the later summer when the roads are dry. Dust will also be emitted during air drilling, but this amount should be small and can be controlled using sprayers.

During the clean-out phase and the standby venting phases, steam will be emitted into the atmosphere. This steam contains noncondensable gases. The primary pollutant contained in the steam is hydrogen sulfide. During the clean-out phase, approximately 360 lbs of H_2S can be expected per well, per day. This period, however, is of short duration. During the longer duration standby venting phase, about 10 lbs of H_2S can be expected per well per day. The resultant increase in the ambient levels of H_2S are computed to be well below the olefactory threshold in the community of Anderson Springs but will exceed this level in the vicinity of the well site. The increased levels, however, do not exceed the toxicity level at any position.

The largest source of vented steam is associated with the power plant rather than the wells themselves. It should be noted that unless mitigation methods are used, the emissions from the power plant may represent an environmental problem.

NOISE

Increased noise levels will occur due to geothermal operations on the site. Most of these effects will be satisfactorily mitigated.

TERRESTRIAL BIOLOGY

Loss of flora and fauna due to removal (directly and indirectly), noise, steam venting, increased erosion, and increased stream turbidity will occur.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

If any geothermal facility were constructed at the location of Geysers 124, the archaeological site would undoubtedly suffer an adverse effect. The effect could range from complete destruction to minor damage, depending upon the nature of the facility.

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

- Careful development and operation will result in short-term, relatively minor impacts on the aquatic resources in the immediate vicinity of development sites.

- Adverse noise impact will occur during the construction and development period. After this initial period, noise levels associated with the project area will be greatly reduced.

- With programs of minimized vegetation removal, erosion control, and revegetation, short-term impacts upon flora and fauna will be minimized and long-term recovery of the site will be accelerated.

- Significant scientific information concerning the history of the particular people who utilized the archaelogical site area as well as information concerning general processes of cultural adaptation would be lost if the archaeological site were destroyed or seriously damaged without mitigation.

- The negative short run socio-economic aspects applicable to the public sector include the increased burden on county government resulting from the administrative and legal costs of the permit application and the hearing procedure itself. The short run negative aspects applicable to the private sector include minimal loss of recreational activity due to the exisience of the Burmah Development. There is also some potential risk of harm to some crops in the area as a result of a possible steam blowout. The short term positive public aspects include increased property taxes available for local government between $150,000 to $200,000 for the steam wells and, when including the plant as well, approximately $375,000 annually.

- The long-run socio-economic costs associated with the Burmah Project, though difficult to calculate, will be associated with public services involving land reclamation, soil conservation and land redevelopment. The steam wells produce sediment, and after thirty (30) to thirty-five (35) years of operation (estimated life), the amount of sediment may be considerable. After the wells are no longer operative, there may be local government costs associated with land reclamation and redevelopment

in the well area. There will be increased local government tax revenues during the entire life of the wells. These tax revenues will be available for long term county projects, such as the development of recreational facilities which would assist the county in increasing its economic base. Increased economic activity due to the Burmah payroll and local purchases would help stabilize the economy and would reduce unemployment fluctuations. The Burmah payroll will result in a multiplier effect of two (2) to three (3) million per year for the next two years and would continue at approximately three-fourths (3/4) of a million per year thereafter.

IRREVERSIBLE ENVIRONMENTAL CHANGES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

The following list summarizes the major irreversible environmental changes which would occur, if the proposed project were implemented:

- Surficial changes due to grading
- Increase in sedimentation
- Disruption of wildlife habitat
- Destruction of one unique archaeological site if the area is not avoided

Specific details of these and other changes are described below.

GEOLOGY

- A small percent of the land surface will be modified by grading.
- There will be a slight increase in runoff, erosion, and sedimentation as a result of grading.
- The proposed development will result in the continuing depletion of existing geothermal resources.
- No subsidence related to geothermal activity in the area is known to have occurred and none is anticipated. However, in the event geothermal production should result in land subsidence, it would constitute an irreversible process.

HYDROLOGY AND WATER QUALITY

An increase in sedimentation of streams due to road building will be nearly irreversible. Although revegetation will reduce the impact over time and scouring during spring spates will transport sediment out of the area, the presence of dirt roads on steep hillsides will be a continuing cause of sedimentation.

TERRESTRIAL BIOLOGY

The loss of some flora and fauna in the area as a result of man's activity will occur.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

If any geothermal development took place at archaeological site Geysers 124, the destruction of the site would be irreversible since the people who were responsible for the fragile pattern of remains no longer follow that life style the site represents. The archaeological site is a non-renewable resource.

GROWTH INDUCING IMPACT OF THE PROPOSED ACTION

- Construction and operation of the proposed industrial facilities will not result in an increase of the population growth rate. It is expected that the maximum number of additional persons which will relocate to the development area as a result of direct permanent employment, will be ten (10) persons. The addition of ten (10) individuals to the Middletown Community will not burden the community.

- Economic activity will be increased as a result of the indirect effects of the proposed project. Increased spending will bring about increased economic activity. While an increased economic base can induce population growth, the growth induced as a result of the proposed project will be minor.

INTRODUCTION

In addition to the Burmah Oil and Gas Company project under consideration, Federal lease lands administered by the Bureau of Land Management (BLM) adjacent to the project area are slated for future development. These lands lie to the south and to the northwest of the proposed project. The BLM has prepared an environmental impact statement for The Geysers geothermal resource area.

This section evaluates the major environmental consequences of development in the BLM area upon the proposed project area. Presentation of issues within the BLM report is also discussed, especially the adequacy and specificity of cumulative impacts and similarity to impacts within the project area. In addition, recommendations as to the types of and methods for continued monitoring programs are presented.

Basically, the BLM report is seen as a general document, not achieving the detail expected in a specific Environmental Impact Statement for a much more sharply defined region. Specific areas are critiqued in the following sections.

GEOLOGIC AND SEISMIC CONSIDERATIONS

The Final Environmental Statement for the Geothermal Leasing Program prepared by the U.S. Department of Interior (1973) has been reviewed in light of the BLM Lease Area adjacent to the Permit Area covered by this report. The Geothermal Leasing Program EIS is necessarily generalized as it covers a great variety of potential geothermal sites. Nevertheless, the EIS presents a reasonably accurate description of the geologic and seismic environment in the vicinity of the site.

The geologic and seismic environment of the BLM Lease Area is very similar to that of the Permit Area described elsewhere in this report. The distribution of earth materials, landslides, and geologic structure within the BLM Lease Area is illustrated on the accompanying Geologic Map. The basic descriptions of the earth materials, physiography, etc. for the Permit Area also apply to the BLM Lease Area.

Impacts from proposed development within the BLM Lease Area on the BLM Lease Area are essentially the same as impacts within the Permit Area. Mitigating measures within the BLM Lease Area are the same as for the Permit Area with the exception that all development must also be reviewed and approved by the Federal Government. The Federal review agency with regard to the geologic and seismic environment is the U.S. Geological Survey.

Development and activities within the BLM Lease Area should have only minimal effect on the geologic environment of the Permit Area. Possible impacts on the Permit Area would be an increase in siltation and sedimentation from increased erosion within the BLM Lease Area. Some additional grading within the Permit Area could also be required as a result of development within the BLM Lease Area. Grading could also be needed for additional or better access roads, pipeline routes, and possibly for an additional power plant.

HYDROLOGY AND WATER SUPPLY

The BLM Report contains several references to water supply and hydrology in the BLM lands to the west and south of the project area. The environmental impacts are essentially the same as those expected in the project area. The major impacts are associated with clearing of vegetation for access roads and well site construction. The BLM report cautions against improper abandonment of field camps and inadequate restoration of those sites. The overall effect on water resources is not considered significant; however, water diversion from critical streams in late summer is considered potentially serious due to dwindling water volumes at that time of year. The flow rates and water quality of all year round streams within or adjacent to the project site should be monitored on a monthly basis.

WATER QUALITY AND AQUATIC BIOLOGY

The most serious and easily criticized fault of the BLM report is a lack of precise information on the environmental impacts and decision trade-offs which will accompany the development of geothermal resources. Public officials, residents and other interested people in an area like Lake County are faced with a number of important choices with regard to geothermal development. On the positive side, there will be increases in employment, some increased local expenditures for goods and services during construction and a long-term increase in the tax base with relatively minor demands on government services. In a larger sense, the general public will presumably benefit from the relatively inexpensive and pollution-free power produced during the lifetime of the resource. On the negative side, any environmental impacts from the project will not only be objectionable in the abstract but will damage the aesthetic resources which are the basis for the county's recreational industry. In the Anderson Springs - Cobb Mountain area these resources are very important. Substantial declines in such things as water quality, fish populations and scenic amenities are likely to be translated directly into declines in the value of recreation property and in income from recreation.

Ideally, decision makers in Lake County would need accurate answers to the following kinds of questions in order to formulate rational policies regarding geothermal development:

1. What volumes of pollutant materials and sediment can be expected to result from development?

2. What will the effect of these levels of materials be on water quality and stream biota?

3. What impact will any such changes have on existing beneficial uses of aquatic ecosystems?

A series of similar questions can arise in connection with social and environmental impacts other than those associated with water quality.

The development of wells on the BLM lease tracts in the Castle Rock area will have impacts on water quality and stream biota substantially similar to those described in the BLM Report sections outlining impacts associated with the private McKinley tract. Fifteen wells are contemplated together with their associated roads and pipelines. All wells will apparently be drilled in the Anderson and Bear Creek drainages, and any impacts will add to the effects from other installations in the area. The BLM Report discusses these impacts in only the most general terms. No primary data of any kind appears to have been collected and the amount of data available from existing sources is meager. Aside from

general impression, gained from experience with existing geothermal development at The Geysers, that properly controlled geothermal power has relatively low impact on aquatic systems, no hard guides to decision-making are evident in the BLM report.

Given the present situation, the protection of water quality and other environmental amenities in the area will require an effective program of monitoring, mitigation, and enforcement of water quality regulations in the area. The following recommendations are offered:

1. Lake County should encourage and, where possible, require monitoring of water quality and other impacts associated with BLM tracts as well as other geothermal developments. (The Bureau of Sport Fisheries and Wildlife is forming a task force for this purpose; Judy Hoffman, personal communication). The County may wish to participate in this project.

2. The County, together with the Water Quality Control Board, Environmental Protection Agency and other agencies, should endeavor to develop regulations which protect environmental values.

3. Planning for water quality protection should include explicit and detailed requirements regarding actions to be taken if serious impacts develop. Given the absence of firm information on the long-term effects of geothermal development, clearly formulated contingency plans will greatly speed action if adverse impacts occur. Contingency planning is a very valuable technique when the various possibilities of impact are understood but when quantitative knowledge of the probability of their occurrence is lacking.

AIR QUALITY

A most important consideration in assessing impacts of geothermal resources on air quality is the effect of all projects simultaneously. Each project, taken by itself, may result in minimal regional impact. However, the total emissions may be hazardous. The BLM report does not include this, since only typical geothermal source emissions are considered.

It is important in this case to consider the permit area developments with the Federal lease land development. The joint consideration will be more important if Federal developments concentrate east of the ridge line, wherein the local wind vector used in the dispersion analysis would pass through the lease land developments, carrying combined emissions to Anderson Springs. This would increase the potential atmospheric concentrations of hydrogen suflide (H_2S).

The present Federal lease land plans appear to project the development in Unit No. 8 on the western slope below the ridge line. In this case, upslope winds with emissions from the Federal wells up to the ridge would probably be further carried by westerly winds above the canyon of Anderson Springs. Thus, it is unlikely that any additional local impact would result from these wells; however, it is eminently possible that they will add to the total burden of pollutants being carried into the Sacramento Valley.

The BLM report does not identify impact regions which would probably be affected along the western slope in Sonoma County. There is no estimate of increases in H_2S which might result from the proposed developments. Impact regions must be delineated for each development so that adequate monitoring can be set up to insure that health standards are not exceeded.

The BLM report recognizes that an ambient air quality problem may exist with H_2S emissions from power plants; however, it is assumed that mitigation devices will be built at power plant sites. In this report there is a question as to the economic feasibility of reducing the amount of H_2S emitted into the atmosphere. This may be a moderating factor in future development of the geothermal resources.

The BLM report is an important source for delineating effects from development of geothermal sources, and has been used extensively in assessing effects of the Burmah Oil and Gas Company developments. However, it is a general analysis of problems rather than specific examinations of given impact regions and fails to analyze the major problem, viz., the total impacts resulting from full development of The Geysers region.

NOISE

The noise impact section of the BLM report, as it relates to geothermal drilling operations, is a mixture of clear-cut expertise and inconsistent and inadequate analysis. Two sections of the BLM report are relevant to the proposed project. The first is a general section on noise measurements, criteria and mitigation, beginning on page III-59 of the report. The second, beginning on page V-55, applies to noise impact at the site.

The criteria section is carefully written, internally consistent and insightful, as is the section on measurements and specific noise criteria. The muffler data, presented in the last portion of this general section, is interesting, but not particularly useful. The flow velocities for which these data are given are five times slower than the ones found at the well heads under study. The pressures are eight times higher in the existing wells than in the data presented so that the types of muffler designs shown would soon be blown apart by the steam flow.

In the section which applies to noise impact at the site, the description of the noise sources is inconsistent. The level given for air drilling while venting with steam (126 dBA) is close to what was measured in the audit. Noise levels decrease according to the following relationship:

$$\Delta L = 20 \log \frac{R_1}{R_2}$$

where R_1 is the distance from the source to measurement point 1 and R_2 is the distance to measurement point 2.

This relationship holds for point sources in the absence of other attenuating mechanisms such as topographical features. Thus, if a noise level is measured at 25 feet which is the case here, its value at 1500 feet will be 35.5 dBA less. The level given for air drilling is 55 dBA at 1500 feet in the BLM report, not the 90.5 which it should have been. The data on a muffled testing well is consistent with other measurements and with the normal distance formula.

The steam venting line noise levels are 25 dBA lower than our measurements, which could be due to lower pressure wells where

these tests were made. The falloff with distance does not agree with the normal law. This time 100 dBA is given as the noise level at 50 feet. The normal falloff would yield a 14 dBA decrease from 50 feet to 250 feet, however the level shown is 90 dBA at this distance. In short, this section is a curious mixture of accuracy and error.

Potential noise impact is dismissed as not being a factor. Venting is said to be accomplished through mufflers, which is not always the case. It is claimed that there are no residential areas in close vicinity to the geothermal region, although Anderson Springs is clearly marked on the chart.

In summary, the overall description of the noise criteria is good, the description of noise sources is mixed and inconsistent, and the noise impact section is inadequate.

The noise impacts associated with the BLM land are similar to those of the proposed project. The mitigation and monitoring programs shown in this report should be incorporated into the geothermal projects on the surrounding BLM lands.

TERRESTRIAL BIOLOGY

The Department of Interior Geothermal Leasing Program Environmental Impact Statement (BLM Report) provides only general guidelines in terms of impacts and mitigation measures related to flora and fauna, while other aspects are adequately discussed.

Impacts upon vegetation and wildlife are discussed minimally. Discussions of local wildlife populations and carrying capacities are not well-developed. Geothermal impacts upon rare and endangered wildlife is also not adequately discussed, except for Peregrine falcons and several raptor species. Specific wildlife habitats to be avoided by development are not defined, except in terms of riparian zones. Fish populations, stream spills, and fish kills are well-treated, however, along with sump construction guidelines to prevent stream impacts. Impacts upon specific terrestrial fauna are not adequately discussed.

Several deer habitat programs are recommended for deer in the Anderson Creek drainage, but are not specified. The BLM report states: "The permanent habitat loss and the overall disturbance will decrease the population of most wilflife species unless other measures are to provide comparable habitat replacement". Specific examples of these measures are not stated, and habitat improvement programs should be thoroughly discussed. Mitigation measures for geothermal development, as related to flora and fauna, are inadequately discussed. Only raptor species losses from transmission lines, and recommended mitigation measures, are specified. Mitigation measures to minimize impact upon the majority of fauna species are not covered.

As Burmah Oil and the Bureau of Land Management work together within the project area, the best possible, and most cost-efficient revegetation programs and erosion control programs, together with other mitigation measures and sound development practices, should be implemented. The guidelines of the BLM report should be followed as general guidelines in formulating an effective mitigation program for geothermal impacts upon flora and fauna. On BLM land within the project site, the EIS provides only a limited baseline for the regulation of geothermal activity. This baseline should be extended into a comprehensive regulatory program. Impacts upon the use permit area from development in the BLM lease area as they affect flora and fauna, are minimal except for impacts originating from one section of BLM land. The ridgeline between the BLM land and the use permit area within the project site divides each section into two constrasting ecosystems. Two separate drainages characterize each area. The hot ridge areas and south-facing exposures covering most of the BLM land are characterized by drier, less-productive vegetative associations. On north-facing slopes in the use permit area, greater available moisture allows more productive vegetative groupings to

exist. Even the Chaparral association within the use-permit area is denser and supports a larger wildlife population than does the Chaparral in BLM land south of the ridge. Minimal wildlife movement takes place between the two sections; separate fauna populations inhabit each section.

Only on the two small northern sections of the BLM land, just north of the ridge and east of Wardlow Rock, do impacts originating from the BLM land affect the flora and fauna of the permit area. In the western BLM land, Padsite CA 956#1 has been developed. The impact from the development of this site is considered as minor adverse, and does not significantly affect adjacent sections of the use permit area.

If development occurred on the eastern BLM land the impact upon the permit area might be severe because a tributary of the Anderson Creek originates here, and on its borders Mixed-Conifer hardwood and Knobcone pine forests grow. Minimal to no development at all is recommended for this general area, north of the ridge, east of Wardlow Rock, and southeast of Camp Verdant Vales. A valuable wildlife habitat area and more productive vegetative communities exist in this area and it is one of the only remaining portions of the project area unaffected by development. In any case, no development whatsoever within one hundred (100) yards of riparian zones is recommended for this section. Impacts within this area would adversely affect wildlife habitat, scenic values, animal corridor routes, and stream quality. Scenic views from the north, particularly from Anderson Creek and Camp Verdant Vales, would be severely affected. A small road cut on the Davies road immediately southeast of this area is visible from Anderson Creek. Future development in this area is not recommended (see vegetation map).

REVEGETATION RECOMMENDATIONS FOR BLM AREAS SOUTH OF THE WARDLOW ROCK RIDGE

This portion of the project site is unique in terms of its low available moisture, hot exposures, and high serpentine intensity. Revegetation in this area is extremely difficult. Only on the east end of the Davies access road are Madrone-Oak associations located, where north-facing slope revegetation measures may be attempted.

Hydromulching techniques with several grass species, and straw-punching methods, were attempted last year along the drier western end of the Davies access road. Hydromulching yielded sparse to good initial cover in some sections, with no results in high serpentine areas. Species used last year on BLM lands were:

Pubescent Wheat	5 lb./acre
Blando brome	4 lb./acre
Harding grass	4 lb./acre
Gerellton subclover	3 lb./acre
Wilton roseclover	3 lb./acre
Perennial rye	4 lb./acre

Germination rates of Blando brome, Perennial rye, and to some extent Gerellton subclover were relatively high for the sites. The Heneke and Serpentine soils on the BLM land are low in calcium-- the Ca/Mg ratios are weighted heavily with Magnesium and present adverse soil conditions for plant growth.

Fertilizers available at the time and used in the operation included:

Triple Super Phosphate	0-18-0 N-P-K ratio	200 lb./acre
Nitrogen Phosphate	13-39-0 N-P-K ratio	200 lb./acre

In addition, Calcium was added to the soils through the use of Gypsum at 1000 lb./acre and it stimulated vegetative growth in the initial revegetation stages. Gypsum was found to be superior to lime for Calcium addition, since lime raised the soil pH.

This coming fall, similar fertilizers, gypsum and heavier amounts of Blando brome, Gerellton subclover, and Perennial rye in the seed mixture, will be used on BLM land revegetation efforts, Hydromulching will not be used as a mulching technique, but a straw-punching process will be attempted. In this technique, straw is first punched into rocky soils with a studded roller. Then seed and fertilizer, along with gypsum, will be applied. Finally straw is punched into the soil again with the roller. This procedure will occur before the first light rains of fall. Again, these rains come usually in mid-October and are light rains that stimulate germination while not disturbing the seedbed. Straw-punching techniques are expected to yield higher results in serpentine areas. Fertilizer will also be applied during seeding and again following the first rains to aid revegetation in its establishment.

In studies conducted by the University of California at its Hopland field station, the Serpentine and Heneke soils were also found to have low sulfur content. Sulfur addition, therefore, is also recommended together with the fertilizers at 500 lbs./acre. If the Triple-super and Single super phosphate fertilizers are used together, however, sulfur additions may not be necessary. These fertilizers do contain some sulfer. Sulfur would have to be added, however, if Triple-super was the only fertilizer used.

Fertilizers and calcium in the gypsum will leach out of the rocky soil layers during the winter and are only used to stimulate the initial growth of revegetation species.

On some high-intensity serpentine sites or in areas where only rocky ground is located, no vegetative establishment may be possible on BLM land. On sites where no natives grow, revegetation efforts should not be attempted. Grass species that can survive on their own, and set seed for the coming spring, are recommended for sites where native brush or grass species already are established adjacent to cleared areas.

Cut slopes in serpentine areas offer chances for little, if any, regeneration. Several such slopes occur near the CA 956 #2 padsite. Cypress transplanting has been mentioned as a possibility for revegetation in this area. This would be difficult, however, and power augers would not work on some of the rocky serpentine slopes adjacent to this padsite and near the Shell ridge access road next to the site. Soil conditions, and the extremely hot exposure at this site, make revegetation efforts almost impossible in this and similar serpentine locations.

In general, revegetation on high serpentine soils can generally be accomplished with the seeding of annual grasses, providing soil conditions are conducive to root development. Direct seeding of manzanita following pre-germination treatment has shown limited success; however it might be worthwhile on a test basis since it grows on serpentine soils. Knobcone pine areas, along the Davies road at lower elevations than the CA 956 #2 padsite and on more fertile soils, can be seeded with grass species and also with local Knobcone pine seed. Slopes along the Davies road in Knobcone pine zones should be planted with 1-0 stock available from the state nursery. Mulching and weed control is suggested for increased survival; straw-punching methods are again recommended. The large (several acres) cut and fill slopes near the present drilling site along the Davies access roads offer somewhat more fertile soils than the serpentine sites on the forestry ridge road. Grass regeneration procedures, using punched straw, should be implemented this fall (Fall, 1975). Regeneration is critical in this area to prevent stream siltation in Bear Canyon Creek.

For serpentine areas and dry exposures, continuing experiments with straw-punching techniques to establish a grass cover are recommended. Although experiments with Coulter pine and Knobcone-Monterey pine cross species should be attempted on a test or trial basis, the survival rate of these species in high serpentine areas will probably be low. If this is the case, then the establishment of woody vegetation for slope stabilization and aesthetics may not be worth the time and expense.

On-site design of padsites and road construction is the best method for

slope stabilization in high serpentine or heneke soils on hot exposures in the project area. The angle of repose on cut and fill slopes should be kept back of 2:1 as much as possible. Burmah Oil has also been using their cats (tractors) to reduce runoff. As the cats go up and down the hills perpendicular to the contours, the cat tracks are parallel to contour lines and break up channels of water flowing down the hill.

In summary, continued experimentation with straw-punching techniques to establish grass cover, and with the planting of tree species from the on-site nursery, should be conducted. Manzanita seeds may also be included with the grass seed mix, following pre-germination treatment. Grass regeneration procedures, using fertilizers, gypsum, and sulfur as mentioned above, are recommended for all cut and fill slope areas in BLM territory this coming fall (Fall, 1975). Exceptions would be sites where no natives grow on the edge of cleared areas in rocky locations, or on steep cut slopes in serpentine areas. Cypress transplanting may be attempted on the fill slopes east of padsite CA 956 #2, and on fill slopes along the Forestry ridge road in BLM territory, in Cypress zones.

To re-emphasize, regeneration on BLM lands above 2500 feet in elevation within the project area is extremely difficult. Pad and road areas have been constructed at a large scale and future BLM development should minimize padsite and sump size. On-site design to minimize runoff and control drainage should be practiced. Along the Davies access road, all drainage culverts should be extended into the edge of adjacent vegetation. Rocks should be put under the lower end of these culverts, to minimize erosion and vegetative disturbance.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

The archaeological element of the Department of Interior's Environmental Impact Statement on the Geothermal Leasing Program as it relates to The Geysers - Clear Lake KGRA has appearances of being hurriedly written, superficial in content, and poorly edited. The superficial coverage of the archaeological background of the area (p. V-65) suggests that the writing was done by someone who was not familiar with California archaeology. For example, the Yokuts are named as a cultural group important in the KGRA. The Yokuts were, in fact, a people who occupied the San Joaquin Valley, from Stockton south to Bakersfield. They had no representatives in the North Coast Ranges or in the KGRA. Yokuts as a term may have been an editorial error substituting for Wappo who were Yukian-speaking inhabitants of the KGRA. The Wappo were not mentioned at all in the BLM report despite the fact that it was reported in the anthropological literature that there was a major Wappo village, Tekenantsonoma, situated at The Geysers.

While it is true that little archaeological research had been conducted in the KGRA at the time the BLM report was prepared, no reference was made to published research directly relevant to the area. Meighan, for example, in 1955 published an important paper on North Coast Ranges archaeology. Unpublished research, available from public agencies in manuscript form, also existed for the area.[55]

The greatest problem with the BLM report is its failure to recommend that archaeological surveys should be conducted on each leasehold and that proper mitigation of adverse effects be carried out. It should be obvious that measures to protect such sites or to mitigate adverse impacts cannot be effective unless the sites are identified, their locations plotted and the sites placed on public record.

Geothermal resources development, since it does involve severe disturbance of the ground surface by massive cutting and leveling, constitutes a severe threat to the integrity of archaeological resources which are relatively fragile surface or shallow subsurface phenomena. Such development can be (and has been) extremely destructive of archaeological resources.

Geothermal development within the BLM land adjacent to the Castle Rock Springs study area will only have indirect effects upon any archaeological resources situated within the study area. Access roads, pipe lines, transmission towers, and power generating plants are obvious sources for potential adverse effect. However, since only one archaeological site was discovered within the Castle Rock Springs study area, it should be possible to prevent damage to the site or to properly mitigate adverse, indirect effects of activities within the BLM lease area.

The Peak assessment of archaeological resources on BLM lands leased by the Burmah Oil and Gas Company was also examined. The BLM lands

are near and adjacent to the Castle Rock Springs project site. The Peak report appears adequate. The major problem in evaluating the work (not the report) was in reconciling the number of acres surveyed by Peak (1160) with the number of person-days required to complete the field work (7-1/2). These figures indicate a daily average per person of about 154 acres. This area is considerably more than the 60 to 100 acres which this writer and his experienced assistants, given similar terrain, have been able to cover in a day's work of conducting intensive archaeological reconnaissance.

In summary, all potential pad sites, roads and pipeline routes should be reconnaissanced prior to construction if any sites are suspected in the area. Mitigation measures will be determined by the field archaeologist after such reconnaissance.

ENVIRONMENTAL CONCERNS

Approximately one hundred and ninety (190) acres of the project site are located in Sonoma County, mostly in the NE 1/4 of Section 34, T. 11 N., R. 8 W, at the county line (Whispering Pines, California (USGS). This site is designated in the Sonoma County general plan for geothermal development. Presently no wells are planned for this area. Should wells be placed there in the future, the impacts and mitigation measures described for the permit area would apply generally to the Sonoma portion of the site as well. Environmental concerns for this area are discussed below.

- The geologic and seismic environment of this portion of the site is essentially the same as the remainder of the site which is located in Lake County. A description of the geologic and seismic environment of the entire Permit Area also applies to the Sonoma County area. The distribution of earth materials and geologic structures within the Sonoma County portion of the site is indicated on the Geologic Map. The only proposed development within the Sonoma County portion of the Permit Area is for pipelines. As the pipelines will basically follow the existing roads in the area, relatively minimal grading and disturbance of natural ground should be required.

- Water quality and hydrology down slope from this site will be affected by grading and disturbance of natural ground cover. No year-round stream is present on this portion of the site.

- The effect of the emissions for the project site on the air quality of Sonoma County will be minimized by two facts. First, the emissions associated with this particular project are small in comparison with the emissions from ongoing operations in Sonoma County; and second, the predominant winds above the ridge line are from the west, and thus even those pollutants carried up-valley will be more or less turned back over the top of Lake County rather than dispersed down into Sonoma County.

- There are no known areas in Sonoma County sensitive to the noise levels of the drilling activities located within the project boundaries addressed here. If wells were to be placed on Sonoma County land, the closest could be approximately 3000 feet from the nearest residence in Anderson Springs and 1300 feet from Verdant Vales. Thus, one (1) dBA would be subtracted from the noise levels calculated for Anderson Springs due to the nearest of the proposed wells and seven (7) dBA would be subtracted from the levels calculated at Verdant Vales. Lake County Use Permit levels would probably be exceeded periodically at one-half (1/2) mile and in Anderson Springs by such activities.

- Flora and fauna in the Sonoma County section of the project area are similar to species found in adjacent Lake County areas of the project site. Stands of mixed conifer, containing hawk nests, are located in the Sonoma section 300-600 yards south of the proposed PG & E Geysers Unit 13 site and 100 to 300 yards west of the forestry ridge road. These stands should be avoided by future development. Chaparral and Knobcone pine communities dominate the remainder of the Sonoma section. Young Douglas-fir trees are coming up through the brush on west-facing slopes, while Knobcone pine predominate on east-facing exposures. The moisture in ocean breezes creates a favorable climate for Douglas-fir reproduction on the west-facing slopes. Wildlife activity is minimal. The site is used by deer primarily as a cover habitat. Apart from the raptor nesting locations and stands of mixed conifer forest mentioned above, there are no unusual flora or fauna species or sensitive ecological areas that would restrict development in the remainder of the Sonoma section.

- This area was at the boundary between the Loknoma Wappo of Middletown and the Tekenantsonoma Wappo of The Geysers. The arcaheological reconnaissance method of this portion of the project site is described elsewhere. Although no archaeological sites were discovered in the Sonoma County portion of the project site, a site had earlier been recorded at the point where Socrates Mine Road crossed the county line about 1000 feet northwest of the Sonoma County portion of the project site. This site, designated Geysers 48, is plotted on the Archaeology Map.

INTRODUCTION

The nature of the geothermal resource in the Castle Rock Springs area is a relatively clean high enthalpy stream contained at depth in rock fissures. Steam at the temperature and pressures encountered here is suitable for extracting work for mechanical or electro-mechanical processes. To best utilize the resource the steam must be kept in tightly confined spaces. Thus relatively narrow wells release the steam to the surface, and transmission pipe lines channel the steam to a plant where work can efficiently be extracted.

Some heat loss is unavoidable in steam pipelines. Therefore, a plant which utilizes the steam must of necessity be located near wells in order to minimize heat loss.

The proposed project itself does not include the construction of a power plant; however, in order to use the resource the plant must be located nearby.

The following section discusses impact of such a power plant on the project site. While the plant itself requires its own environmental impact report, siting can be evaluated with respect to parameters associated with the proposed project.

GEOLOGY

If wells in the southern portion of the Permit Area and the adjacent BLM area encounter good steam production, a power plant in this area will be required. A basic restraint on the location of geothermal power plants is that they should be located within about 3000' of the steam wells to reduce heat loss. In addition, the sites must be geologically stable and good access must be available.

Within the southern portion of the area, reasonably good access is available along the Davies Access Road. The power plant site should be located as near as possible to the road to minimize additional grading. Two possible sites within the Permit Area are the ridge crest about 500' directly west of the Barrows Well site or the saddle about 900' northwest of the Barrows Well site. The ridge site is closer to the road, but would probably require a greater amount of grading to lower the ridge and create the necessary level building area. The saddle site is further from the road and would require more grading for road access. It would apparently involve less actual site grading to create level building areas. Available geologic data indicates that these sites are apparently stable. The saddle site has two adjacent landslides, however, which

need study. Prior to the selection of any power plant site in the area, very thorough and detailed site investigations should be performed by a licensed civil engineer experienced in soil mechanics and foundation engineering and by a certified engineering geologist experienced in slope stability analysis. Any accepted site should be certified as stable by the engineer and geologist.

HYDROLOGY AND WATER QUALITY

The power plant site should be selected to minimize grading and vegetation removal and to maximize the distance from surrounding streams.

AIR QUALITY

Estimated quantities of H_2S to be emitted from the geothermal plants (assuming no abatement) for the next several years are given in Table 12. Burmah Oil and Gas already has 13 wells venting in the Castle Rock Springs area north of the new well sites. These emit totals of about 130 lbs. of H_2S/day and when additional needed wells are completed, a total of about 200 lbs/day of H_2S will be emitted. Based on data from Burmah, 13 existing wells in the Castle Rock Springs area, on standby, are venting about 4,000 lbs. of steam an hour or about 10 lbs. of H_2S/day/well.

Table 12

Hydrogen Sulfide Emissions from The Geysers Power Plant
1974-78 (tons/day)

Year	H_2S Emissions Without Abatement Program	H_2S With Abatement Program as Scheduled	Total Generating Capacity Available
1974	20 tons	20.0 tons	395 MW
1975	25 tons	20.5 tons	502 MW
1976	36 tons	11.8 tons	718 MW
1977	45 tons	8.0 tons	908 MW
1978	51 tons	5.1 tons	1,018 MW

Source: PG&E and Enviros

About 5.3 miles further west, over the ridge line dividing Lake and Sonoma County, are the first 10 PG & E units at The Geysers which currently produce about 16 to 19 tons of H_2S/day.[42] These latter figures represent maxima since no pollution abatement and full operation are assumed. Based on these data, the incremental increase in H_2S from the venting of the project wells would be approximately 60 lbs of H_2S/day, which is small compared to the background emissions from the above-mentioned production facilities.

Emissions from the venting of projected wells are based on actual measurements made by Burmah on wells in the Castle Rock Springs field. Other data indicate a spread of H_2S concentrations from 0.005% to 0.160% by weight and an average from 47 producing wells measured in 1972 as 0.027% weight. The Burmah value is approximately .01%, considerably lower than average and the maxima reported from other well sites in The Geysers region.

Average amount of ammonia emitted is approximately one-quarter the amount of hydrogen sulfide. However, due to a difference in molecular weight, this represents only a twofold change in the mole or volumetric percentage. Therefore, in terms of the total ammonia added to the atmosphere, divide the hydrogen sulfide values by four; but later, in describing the dispersion of pollutants, concentrations of H_2S are given in ppm (volume fraction). In these cases, the ammonia concentration can be approximated by dividing the H_2S concentrations by two.

NOISE

Estimates of the expected noise levels associated with geothermal plants vary greatly. The Federal EIR projects 117 dBA at 50 feet for example while the Enviros EIR done on the Davies site projects 85-90 dBA at the same distance. In general, the plant may be assumed to be a source of noise and thus from the standpoint of considerations of minimizing its impact solely through plant location, the greatest distance practical should be left between the plant and sensitive locations. Where possible the plant should also be located behind intervening hills or ridges.

TERRESTRIAL BIOLOGY

A site associated with the lowest possible level of flora and fauna disturbance should be selected for the proposed power plant. Present drilling operations near Big Injun Mine, on the ridge near the Davies

road, are visible from Anderson Creek. In terms of visual impact, the plant site should not be located on the ridgeline.

A potentially critical habitat zone for the Peregrine falcon, a rare and endangered species, is located from Wardlow Rock south to the Davies road, are visible from Anderson Creek. In terms of visual impact, the plant site should not be located on the ridgeline.

Five acres of brush have already been cleared to construct a drilling sump along the Davies road. This sump is adjacent to cleared ground at Big Injun Mine. It is also on the Bear Canyon Creek side of the ridge, hidden from Anderson Creek. In this location the slope to the south of the Davies road is less severe. Wildlife activity in the area is minimal; Chaparral is the only habitat type present. In terms of vegetation disturbance and erosion, a majority of the vegetative cover required for a power plant has already been removed at this site. Minimal additional clearing of vegetative cover would be required. Stream siltation problems could develop in Bear Canyon Creek from development on this location. Since most of the site has been cleared, however, this is a present impact to be mitigated rather than a future consideration.

Plant site locations north of the above mentioned drilling site could be considered. These areas are steep and sensitive riparian zones are in close proximity. A large amount of vegetative disruption (over 10 acres) in Madrone-oak woodland areas would also occur. A more valuable biological structure and wildlife habitat, than found in the Chaparral south of the Davies road, would be disturbed in this location. For these reasons, development north of the ridge is neither aesthetically nor biologically desirable and is not recommended.

Construction sites could also be considered along the Davies road, slightly south of the ridge and west of the present drilling site on the road. These areas may not be large enough for the site, however. A large volume of dirt required for fill slopes in the area would cause significant biological impacts.

Should the area adjacent to the intersection of the forestry ridge road (the Shell access road) and the Davies access road not be designated as part of a critical falcon habitat zone, this location would be a reasonable site. There is sufficient level ground for the plant, and wildlife impact would be minimal. Cypress, Chaparral, and stunted stands of Knobcone pine support a limited variety of wildlife in this location. Riparian zones would not be disturbed. Aesthetically, the plant would stand out sharply in contrast with the flat saddle area and its low-lying vegetative cover at this site. This aspect would not be desirable.

Under no circumstances should the power plant be developed on Bear

Canyon Creek. Development north of the ridge, as previously mentioned, is also discouraged. The existing drilling sump along the Davies road could be considered, along with the road intersection area, for the least biological intrusions. In any event, a detailed environmental study should be undertaken to determine the most advantageous site possible.

ARCHAEOLOGICAL AND SCIENTIFIC RESOURCES

Since no archaeological resources were discovered immediately north of Big Injun Mine at the south end of the Lake County portion of the study area, the installation of the proposed power plant in the general vicinity will not adversely affect archaeological resources.

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SOURCE MATERIALS

1. Adams, D.F. 1974. Environmental Impact Statement for Proposed Expansion of the Hoerner Waldorf Pulp and Paper Mill at Missoula, Montana, 1974. Montana Dept. of Health and Environmental Sciences, Helena, Montana.

2. Agricultural Commissioner, Lake County, 1954-1974. "Agricultural Crop Report."

3. Allen, D.R., 1973. Subsidence, Rebound and Surface Strain Associated with Oil Producing Operations, Long Beach, California, in Geology, Seismicity, and Environmental Impact, Association of Engineering Geologists, Sp. Pub.

4. Armstead, H.C. 1973. Geothermal Energy: Review of Research and Development, UNESCO Paris

5. Personal communication with Mr. Ralph Austerling, Environmental Quality Department, Pacific Gas and Electric Co., 77 Beale Street, San Francisco, California. 94106. June 19, 1975; July 16, 1975.

6. Austerling, Ralph. Public Utilities Commission. Testimony given during hearings for the proposed Unit 12 of the Geysers Power Plant System. San Francisco, California. Pacific Gas and Electric Company related hearings. March 14, 1973.

7. Barrett, S.A. 1908. "The Ethnogeography of the Pomo and Neighboring Indians." University of California Publications in American Archaeology and Ethnography 6:1-332.

8. Barton, David B. 1972. "The Geysers Power Plant--A dry Steam Geothermal Facility," in Compendium of First Day Papers presented at the First Conference of the Geothermal Resources Council, El Centro, California.

9. Personal communication with Mr. Lee Ballou, U.S. Forest Service, Upper Lake, Lake County, California. June 13, 1975; July 3, 1975.

10. Benedict, H. M., and Breen, W. H. The Use of Weeds as a Means of Evaluating Vegetation Damage Caused by Air Pollution. Proceedings of the Third National Air Pollution Convention. April 18-20, 1955. Pasadena, California.

11. Bishop, Bruce. Measurements made in Anderson Springs, California.

12. Bolt, B.A., 1973. "Duration of Strong Ground Motion". Fifth World Conference on Earthquake Engineering, Rome.

13. Bolton, R.S. 1973. "Management of a Geothermal Field" in, H.C.H. Armstead, ed., Geothermal Energy: Review of Research and Development: UNESCO, Paris, France, pp. 175-184.

14. Bowen, R.G., 1973. "Environmental Impact of Geothermal Development" in Geothermal Energy (ed: Kruger and Otte).

15. Box, W.T., 1975. Map of Landslides, Castle Rock Springs Area, Burmah Oil, unpublished map.

16. Brandt, C.S. and Heck, W.W. 1968. "Effects of Air Pollutants on Vegetation." pp. 401-443 in Air Pollution, Second Edition, Vol. I.

17. Brice, J.C., 1953. "Geology of the Lower Lake Quadrangle, California" in California Div. of Mines and Geology Bull. 166.

18. Brown, Vinson. The California Wildlife Region. Naturegraph Publishers, Healdsburg, California. 1965.

19. Brown, Vinson, Henry Weston, and J. Buzzell. 1973. Handbook of California Birds. Naturegraph Publishers, Healdsburg, California.

20. Burmah Oil & Gas. February 21, 1975. Chemical Analysis, Bear Canyon Creek.

21. Burmah Oil & Gas. December 30, 1974. Interoffice Communication: Steam Condensate Sample from"Thorn" No. 3.

22. Burmah Oil & Gas. May 14, 1975. Plan of Operation

23. Cadle, R.D. and M. Ledford. 1966. International Journal of Air and Water Pollution 10, 25.

24. California Division of Mines and Geology. 1972. Preliminary Earthquake Epicenter Map of California, 1934-1972: Seismic Safety Information, 72-3.

25. California Division of Mines and Geology. 1973. State of California, preliminary fault and geologic map: Preliminary Report 13, Scale 1:750,000.

26. California Department of Water Resources. 1964. "Crustal Strain and Fault Movement Investigation", Bull. No. 116-2, 96p

27. Cameron, M. and Cushman, M. 1952. Vegetation-Soil Map (60A-3) for Lake and Sonoma Counties, U.S. Department of Agriculture Publication.

28. Carlson, Clinton E. 1974. "Sulfur Damage to Douglas-fir Near a Pulp and Paper Mill in Western Montana." Report No. 74-13. U.S. Department of Agriculture, Forest Service. Region 1, Missoula, Montana.

29. Carlson, Dale A., Leiser, Curtis and Gumerman, Robert. The Soil Filter, A Treatment Process for the Removal of Odorous Gases. Report for the Federal Water Pollution Control Administration. Microfiche #PB 202580. University of Washington. Seattle, Washington.

30. Chasteen, A.J. n.d. Geothermal Steam Condensate Reinjection.

31. Clark, W.B. and Hauge, C. J. 1971. "When the Earth Quakes, You Can Reduce the Danger" in California Geology, v. 24, p. 200-216.

32. Coffman, J.L. and von Hake, C.A., eds., 1973. Earthquake History of the United States: U.S. Department of Commerce, NOAA, Environmental Data Service, Pub. 4--1, rev. ed. (through 1970). p. 208.

33. Committee on Interior & Insular Affairs. December, 1973. The Potential for Energy Production from Geothermal Resources.

34. J. M. Covington Corporation. June 19, 1973. Geothermal Steam: Study to Establish Steam Gathering System Design Criteria for Signal Oil & Gas Co.

35. Cox, R.A. and F J. Sendallis. 1974. "The Photo Oxidation of Hydro gen Sulphide and Dimethal Sulphide in Air" in Env. 8.

36. Cramer, H.E. et al. June, 1974. Comments on Sections IV.E (Air Quality Impact) and VI.B (Adverse Air Quality Effects) of a 15 May 1974 Draft Environmental Impact Report Prepared by Ecoview Environmental Consultants.

37. Daubenmire, Rexford. 1968. Plant Communities, Harper and Row, Publishers, New York, N.Y.

38. Driver, H.E. 1936. Wappo Ethnography. University of California Publications in American Archaeology and Ethnography 36(3):47-118.

39. Duffy, John. April 13, 1970. Analysis of Non-Condensables in Geothermal Steam (Inter-Office Communication).

40. Eckel, E.B. (ed). 1958. "Landslides and Engineering Practice." Highway Research Board, Sp. Rpt. 29, 232p.

41. Ecoview, Environmental Consultants. November, 1974. California Geothermal Incorporated Cobb Mountain Leasehold, Lake County, California.

42. Ecoview, Environmental Consultants. February, 1975. Draft EIR for the Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, CA.

43. Ecoview, Environmental Consultants. December 19, 1974. Pacific Gas & Electric Company, Comments on Environmental Impact Analysis, Shell Oil Company Proposed Geothermal Well, U.S. Geothermal One Well #1.

44. Ecoview, Environmental Consultants. February, 1975. Shell Oil Company, Proposed Geothermal Well, Bounsall Lease Well #1, Lake County, California.

45. Ecoview, Environmental Consultants. February, 1974. Union Oil Corp. Proposed Horner-State #1 Geothermal Well, Lake County, California.

46. Ecoview, Environmental Consultants. January, 1974. Geothermal Development, Leaseholds of Geothermal Kinetics and Pacific Energy, Inc. of the Geysers.

47. Environmental Assessment Engineering. February 1, 1974. Proposed Geothermal Resource Development Davies Estate Property (Supplemental Environmental Impact Analysis.)

48. Environmental Protection Agency, Levels Document.

49. Enviros. February, 1975. Draft Environmental Impact Report: Burmah Oil and Gas Company, Castle Rock Springs Geothermal Steam Field Expansion, Dillingham Property, Lake County, California

50. Enviros. August 14, 1974. Final EIR, Vol. 3 Review, Analysis, Recommendations: Geothermal Development, Burmah Oil and Gas, Davies Estate.

51. Erismann, K.H., et al. 1968. Sulfate Increases in Leaves During Favorable Photosynthesis Periods. Flora Abstracts. A Physiological Biochemistry (Jena) 159 (5) 379-382.

52. Evans, D.M. 1970. "The Denver Area Earthquakes and the Rocky Mountain Arsenal, Denver, Colorado". Engineering Geology Case Histories, n. 8, Geological Soc. America.

53. Evans, D.M. 1966. "Man-Made Earthquakes in Denver" : in Geotimes, v. 10, no. 9, pp. 11-18.

54. Ford, H.W. 1973. Levels of H_2S Toxic to Citrus Roots. Journal of American Society of Horticultural Science. 98 (1), pages 66-68.

55. Fredrickson, D.A. 1961. The Archaeology of Lak-261, a Stratified Site near Lower Lake, California. MS on file with the California Department of Parks and Recreation, Sacramento.

56. Fredrickson, D.A. 1974. Cultural Diversity in Early Central California: A View from the North Coast Ranges. Journal of California Anthropology (1 (1): 41-53.

57. Fredrickson, D.A. 1973. Early Cultures of the North Coast Ranges, California. Unpublished doctoral dissertation, University of California, Davis.

58. Personal communication with Mr. George Frye, Division Engineer, Geothermal Division, Burmah Oil and Gas Co., Santa Rosa, California. July 10, 1975.

59. Geothermal Resources Board of the State of California. 1971. "The Economic Potential of Geothermal Resources in California." A response to senate resolution No. 331. (1970).

60. Geothermal Resources Council, Geothermal Overviews of the Western United States 1972, El Centro, California. 1972.

61. Geothermal Resources Board. August 1974. Minutes of the Geothermal Resources Board Meeting.

62. Glater, R.A. March, 1970. Smog and Plant Structure in L.A. County. UCLA School of Engineering and Applied Science.

63. Glaves, S. and S. Tody. 1975. "Reaction Between Ozone and Hydrogen Sulphide" in Journal of Phy. Chem., 79.

64. Goldman, George, et.al. November, 1973. Lake County Economic and Resource Use Study for Base Year 1975.

65. Gowans, K.D., 1967. Soil survey of Tehama County, California: U.S. Dept. of Agriculture, Forest Service and Conservation Service and U.C. Agriculture Experiment Station: U.S. Govt. Printing Office, Washington, D.C., 124pp.

66. Greensfelder, R.W. 1974. "Maximum Credible Rock Acceleration from Earthquakes in California" California Div. Mines and Geology, Map Sheet 23.

67. Gutsell, J.S. 1921. Bureau of Fisheries, Document No. 910, Appendix VII to the Report of the U.S. Commissioner of Fisheries for 1921, Dept. of Commerce, Bureau of Fisheries 10 pp.

68. Hahn, Wise and Assoc. April 1972. (Amended August 1972). Conditions, Procedures, and Performance Standards for Geothermal Regulation: County of Lake.

69. Hahn, Wise and Assoc. September 25, 1967. Lake County General Plan.

70. Hahn, Wise and Assoc. September 25, 1974. Lake County General Plan.

71. Hahn, Wise, and Assoc. August, 1973. Lake County, Open Space Conservation Element of the General Plan.

72. Hahn, Wise and Assoc. February, 1971. Lake County, Public Services & Facilities Element of the General Plan.

73. Hahn, Wise and Assoc. August 1973. Lake County, Scenic Highway Element of the General Plan.

74. Hamilton, R.M. and Muffler, L.J.P., 1972. Microearthquakes at the Geysers Geothermal Area, California: Journal of Geophysical Research, vol. 77, no. 11, p. 2081-2086.

75. Handbook of Noise Control, C. M. Harris, McGraw Hill, 1957.

76. Handbook of Noise Measurement, General Radio.

77. Harr, Dennis R., W. C. Harper, J. T. Krygier, and Frederic S. Hsieh, Changes in Storm Hydrographs after Road Building and Clear-Cutting in the the Oregon Coast Range, Water Resources Research, Vol. 11, No. 3, June, 1975.

78. Hatton, J.W. 1970. Ground subsidence of a geothermal field during exploration: United Nations Symposium on the Development and Utilization of Geothermal Resources, Pisa, Italy.

79. Hearings before the Committee on Interior and Insular Affairs, U.S. Senate - Geothermal Energy Resources and Research, June 15 and June 22, 1972. U.S. Government Printing Office, Washington, D.C.

80. Heizer, R.F., editor. 1953. The Archaeology of the Napa Region. University of California, Anthropological Records 12 (6): 225 358.

81. Herbert, D.W.M. and J.C. Merkins 1961. "The Effect of Suspended Mineral Solids on the Survival of Trout." Int. J. Air Wat. Pol. 5: 46-55.

82. Ishii, Tonio, September 1971. "Air Pollution Control for Kraft Pulp Mil with Ozone." Journal of Pollution Control, 7 (9): 824-828.

83. Jensen, G.A., et al. 1966. Absorption of Hydrogen Sulfide and Methyl Mercaptan from Dilute Gas Mixtures. Journal Air Pollution Control Association: 16 (5): 248.

84. Koenig, J.B. 1963. Geologic map of California, Santa Rosa sheet: California Div. Mines and Geology.

85. Kroeber, A.L. 1925. Handbook of the Indians of California. Bureau of American Ethnology, Bulletin 78.

86. Kruger P. and C. Offe. 1973. Geothermal Energy: Resources Production, Stimulatia, Stanford, California.

87. Kuby, W.C., n.d. Environmental Impact Study - Geothermal Power Plant. (Xerox 6 pp.)

88. Lake County, Department of Agriculture. 1974. Agricultural Crop Report.

89. Lake County, Department of Agriculture. August 1974. Regulations of The Lake County Air Pollution Control District.

90. Lake County Economic and Resource Use Study, Agricultural Extension, University of California, November, 1973.

91. Lake County. 1971. EIR Guidelines.

92. Lake County. General Plan. Adopted September, 1967.

93. Lake County. General Plan. Housing Element. January 1971.

94. Lake County. General Plan. Public Services and Facilities Element. February 1971.

95. Lake County Planning Commission. April, 1975. Final EIR Shell Oil Company Proposed Geothermal Well - U.S. Geothermal One Well #1.

96. Lake County Planning Commission, September, 1974. Final EIR Union Oil Corp. Proposed Drilling Site Horner State #1 Geothermal Well.

97. Lake County Planning Commission. May, 1971. Report Regarding Eureka Magma Exploration Company use Permit Public Hearings.

98. Lake County Planning Commission. April, 1975. Resolution No. 75-46, Shell Oil Company Use Permit Geothermal Well #1.

99. Lake County Planning Commission. June, 1971. Resolution No. 71 - Use Permit - Eureka Magma Exploration Company.

100. Lake County, State of California. 1974. Final Budget, 1974-1975.

101. Lawson, A.C. and others, 1908. The California Earthquake of April 18, 1906. Report of the State Earthquake Investigation Commission; Carnegie Institution of Washington, Washington, D.C., VI and II.

102. Lectures on Transportation Noise, R. H. Lyons, Grozier, 1973.

103. Leopold, A. Starker. Game Birds and Mammals of California, A Laboratory Syllabus. University of California Press, Berkeley, California. Revised, 1956.

104. Levy, H. 1974. "Photochemistry of Troposphere" in Adven. in Photochem., 9.

105. Liuti, G., et al. 1966. "The Reaction of Hydrogen Sulphide and Atomic Oxygen" in J.A.C.S., 88.

106. Lofgren, B.E. and Klausing, R.L., 1969. Land subsidence due to ground-water withdrawal, Tulare-Wasco area, California: U.S. Geological Survey Prof. Paper 437-B

107. Lowney-Kaldveer Assoc. July 10, 1973. Proposed Unit 13 Geysers Power Plant Sites 1, 2, 3 & 5 and Areas 1 & 2.

108. McCallan, S.E.A.; Hartzell, Albert; and Wilcoxon, Frank. Hydrogen Sulfide Injury to Plants. Contributions to Boyce Thompson Institute. (8). 198, 197.

109. McLaughlin, R.J. 1974. Preliminary geologic map of the Geysers steam field and vicinity, Sonoma County, California: USGS open file map 74-238.

110. McLaughlin, R. J. 1975. Preliminary field compilation of in-progress geologic mapping in the Geysers geothermal area, California: USGS open file map 75-198.

111. Meighan, C.W. 1955. Archaeology of the North Coast Ranges, California. University of California Archaeological Survey, Reports 30: 1-39.

112. Miller, V.C. 1972. Soil survey of Sonoma County, California: U.S Dept. of Agriculture, Forest Service and Conservation Service and U.C. Agriculture Experiment Station: U.S. Govt. Printing Office, Washington, D.C., 188pp.

113. Munson, R.C. 1970. Relationship of effect of waterflooding of the Rangely Oil Field on seismicity: Engineering Geology Case Histories, n. 8, Geological Soc. America.

114. Munz, P.A., and Keck, D.D. A California Flora. University of California Press. 1968.

115. Natural Resources of Northwestern California, Recreation Resources Supplement, Economic Aspects, Department of the Interior, June, 1957.

116. Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances, EPA, 1971 prepared by Bolt, Beranek & Newman NTID300.1.

117. Office of Planning & Research. October, 1974. Maps & Publications for Areas of Potential Environmental Critical Concern.

118. Pacific Gas & Electric Company. May 9, 1975. Comments on Environmental Impact Analysis: The Geothermal Leasehold of Union Oil Company at the Geysers, Sonoma County, California.

119. Pacific Gas & Electric Company. 1974. Environmental Data Statement, Geysers Unit 13.

120. Pacific Gas & Electric Co. December 13, 1974. Hydrogen Sulfide in Main Steam (ppm_w) The Geysers.

121. Pacific Gas and Electric Company, Department of Research. 1974. Known Geothermal Resource Area Fishery Investigations.

122. Page, B.M. 1966. Geology of the Coast Ranges of California in E. H. Bailey, ed., Geology of Northern California: California Division of Mines and Geology Bull. 190, p. 255-276.

123. Peak, Ann S. October, 1974. Archaeological Assessment of Cultural Resources on Geothermal Leaseholds in Lake & Sonoma Counties, California.

124. Plapp, Jr. 196. Engineering Fluid Dynamics.

125. Ploessel, M.R. and Slosson, J.E. 1974. Repeatable High Ground Accelerations from Earthquakes - Important Design Criteria: California Geology, v. 27, n. 9, p. 195-199.

126. Prospectus: "Investment Possibilities of the Geothermal Resources in the Imperial Valley," California, Prepared by Transeesco, May, 1974.

127. Public Opinion Survey, College of Natural Resources, University of California and the Planning Department, Lake County, June, 1975.

128. Robbins, Chandler S., Bruun, Bertel, and Sim, Herbert S. Birds of North America. Golden Press, New York, New York. 1966.

129. "Salton-Mexicali Geothermal Province," in Mineral Information Service, Division of Mines and Geology, State of California, Volume 20, Number 7, July 1967.

130. Schnabel, P. B., and Seed, H.B. 1973. "Acceleration in Rock for Earthquakes in the Western United States". Seismological Soc. America, Bull. 63, n. 2.

131. Shapiro, A.H. 1953. Dynamics and Thermodynamics of Compressible Fluid Flow 1. Ronald Press.

132. Singer, I.A. and Smith, M.E. 1966. International Journal of Air and Water Pollution.

133. Smith, J. H. October 15, 1958. "Production and Utilization of Geothermal Steam". New Zealand Engineering.

134. Smith, L.L. and D. M. Oseid. 1972. "Effects of Hydrogen Sulfide on Fish Eggs and Fry." Water Res. 6: 711-720.

135. Society of Petroleum Engineers. 1975. Environmental Constraints on Geothermal Development.

136. State of California. Air Resources Board. Ambient Air Quality Standards. 1970.

137. State of California. June 1974. Air Resources Board, Sacramento. Summary of Lake County Mobile Air Monitoring.

138. State of California. 1957. Water Pollution Control Board Publication Number 3, Sacramento, California.

139. Steinbrugge, K.V., et al. 1970. "The Santa Rosa, California Earthquakes of October 1, 1969." U.S. Department of Commerce, Environmental Science Services Administration, Rockville, Md.

140. Stern, A. 1968. Air Pollution, Vol. III. Academic Press, New York, page 660. Second Edition.

141. Stitchting. 1966. "The Calculation of Atmospheric Dispersion from a Stack" in Concawe.

142. Stuhl, F. 1974. "Determination of the Rate Constant for the Reaction OH + H_2S by Pulse Photolysis - Resonance Fluorescene Method" in Busenges. Physik. Chem., 78.

143. Sweeney, James. "Ecology of Some Fire Type Vegetation in Northern California." Proceedings of the California Tall Timbers Fire Ecology Conference, Nov. 9-10, 1967.

144. Tax Rates and Tax Assessment Valuation/Lake County. Assessor, Lake County. 1965-1966; 1969-1970; 1971-1972, 1972-1973; 1973-1974.

145. Transeesco. May, 1974. Prospectus: Investment Possibilities of the Geothermal Resources in the Imperial Valley, California.

146. Department of Transportation. Population Division. State of California. Immigration Studies and Population Reports, 1970-1975.

147. Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines, EPA, 1971 prepared by Wyle Laboratories PB 208-660.

148. Personal Communication with Mr. Fayne Tucker, Lake County Air Pollution Control District, Lake County, California. 95453. May 5, June 13, 1975.

149. United States Congress. December 24, 1970. Public Law 91 581: Secretary's Regulations.

150. U.S. Department of Interior. 1973. Final Environmental Statement for The Geothermal Leasing Program, 4 vols.

151. U.S. Department of Interior. May, 1974. U.S. List of Endangered Fauna.

152. U.S. Department of Interior, Bureau of Land Management. January 1975. Environmental Analysis Record: Proposed Federal Geothermal Leasing.

153. U.S. Department of Interior, Bureau of Land Management. December 21, 1973. Geothermal Resources: Leasing on Public Acquired & Withdrawn Lands.

154. U.S. Department of Interior, Bureau of Reclamation November, 1956. Natural Resources of Northwestern California: Report Appendix - Landuse, Land Classification, Timber Resources.

155. U.S. Department of Interior, Bureau of Reclamation. 1960. Natural Resources of Northwestern California: Report Appendix - General Economy.

156. U.S. Department of Interior, Bureau of Reclamation. 1960. Natural Resources of Northwestern California: Report Appendix - Plans of Water Development.

157. U.S. Department of Interior, Bureau of Reclamation. 1960. Natural Resources of Northwestern California: Report Appendix - Water Requirements.

158. U.S. Department of Interior, Fish & Wildlife Service. 1960. Natural Resources of Northwestern California: Report Appendix - A Preliminary Survey of Fish and Wildlife Resources.

159. U.S. Department of Interior, U.S. Geological Survey Water Resources Data for California, Part 1. Surface Water Records, Volume 1.

160. U.S. Department of Interior, Geological Survey, Water Resources Data for California, Part 1, Surface Water Records, Volume 1. Averages based on flow from 1904-1971.

161. U.S. Department of Interior, Geologic Survey, Eel River Study. 1974. U.S. Department of Interior in cooperation with the California Department of Water Resources, March 1974.

162. U.S. Department of Interior, Geologic Survey. October, 1956. Natural Resources of Northwestern California: Preliminary Report Appendix - Water Resources.

163. U.S. Department of Interior, Geological Survey and the Bureau of Mines. 1960. Natural Resources of Northwestern California: Report Appendix - Geology, Mineral Resources, Mineral Industry.

164. U.S. Department of Interior, National Park Service. June, 1957. Natural Resources of Northwestern California (Preliminary Report Appendix).

165. U.S. Department of Interior, National Park Service 1958. Natural Resources of Northwestern California: Preliminary Report Appendix - Recreation Resources.

166. U.S. Department of Interior, National Park Service. May 1958. Natural Resources of Northwestern California: Preliminary Report Appendix - Recreation Resources, Supplement History and Archaeology.

167. U.S. Department of Interior, Pacific Southwest Field Committee. 1956. Natural Resources of Northwestern California: Preliminary Report.

168. U.S. Department of Interior, Pacific Southwest Field Committee. 1960. Natural Resources of Northwestern California: A Report on Conservation and Utilization.

169. U.S. Census, 1880 to 1970.

170. University of California, Berkeley, 1973. Catalogue of Northern California Earthquakes, 1910-1971: Seismographic Station, Computer Readout.

171. University of California. June 1975. Environmental Study of Prospective Geothermal Development in Big Canyon Creek Watershed, Lake County, California.

172. Wang, C.C. and L.I. Davis, 1974. "Measurement of Hydroxol Concentration in Air Using a Tuneable UV Lasar Beam" in Phy. Rev. Let. 32.

173. Yates, R.G. and Hilpert, L.S. 1946. "Quicksilver Deposits of Eastern Mayacmas District, Lake and Napa Counties, California:" California Jour. Mines and Geology, Vol. 42, n. 3, p. 231-286.

174. Young, Joseph F., "Prospectus: Investment Possibilities of the Geothermal Resources in the Imperial Valley, California," prepared for Transeesco--A Joint Venture, May 1974.

175. Department of Water Resources. March, 1974. Hydroelectric Energy Potential in California.

176. Anspaugh, L.R. and P.L. Phelps. March, 1975. "Interim Report on the Investigation of the Impact of the Release of ^{222}Rn, its Daughters, and Possible Precursors at The Geysers Geothermal Field and Surrounding Area."

APPENDIX A

SPECIFICATION FOR PREPARATION
OF
DRILL SITES AND ACCESS ROADS

Prepared by Hawke Engineers

July 29, 1974

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1.01 INTRODUCTION

The following specifications and attachments shall be adhered to for geothermal drilling sites and access road construction throughout the Castle Rock Springs Geothermal Project. The specifications are of a general nature and may require special engineering attention and construction techniques on separate and unique situations.

Cases involving special consideration and construction techniques are enumerated in Section 8 of these specifications and are entitled under "Special Conditions".

2.01 DRILL SITE LOCATIONS

Drill site locations shall be selected utilizing natural topographic features such as ridges, benches, shoulders, and valleys which provide relatively flat areas of sufficient size to accomodate the drilling facility.

Where cuts and fills are required, the site shall have sufficient catch points for the fill to rest on safely.

The site shall be engineered to balance cuts and fills, thereby minimizing changes in natural contours, excavation operations, and disturbance of vegetation.

Areas of past landslides are to be avoided, or stabilized during construction.

2.02 ROAD LOCATIONS

Access roads shall follow existing trails where possible, in keeping with good design and construction practices.

Road widths will be limited to the width required for safe equipment operation. In general, road widths shall be designed to safely accomodate heavy drilling equipment.

Turnouts shall be provided at strategic locations.

Roads shall follow natural contours of the land, with grades limited to 18%.

Balanced cut and fills shall be utilized.

3.01 CONSTRUCTION TECHNIQUES

Construction areas will be stripped of vegetation and topsoil. The vegetation will be stockpiled and burned, or buried in spoil areas. The top soil will be stockpiled for later spreading over cut and fill areas to enhance revegetation.

3.02 ENGINEERED FILLS

All fill areas will be benched and keyed into undisturbed ground. Beginning at the base of the slope, excavate a substantial key into sound, undisturbed original soil or rock.

Embankments will be placed in 6" to 8" lifts, moistened as required, and compacted by tamping rollers or other approve compacting equipment to 95% of ASTM D-1557-70, "Moisture Density Relations Test for Soils".

Compacted outer-fill slopes less than 30' in height shall not exceed 1 vertical on 1.75 horizontal and slopes over 30' in height should not exceed 1 vertical on 2.0 horizontal and shall be benched. Height between benches shall not exceed 25'.

At the top of all fill slopes, construct a 3' high beam of compacted soil to prevent any surface water slope wash.

Seed or plant all slopes, to stabilize the soils, control erosion and restore aesthetic value of property.

Along access roads, construct a similar compacted berm to prevent slope wash and to direct all surface flow towards roadway ditches.

At the drill locations slope surface to drains and provide a system of ditches with culverts under access roads so that all water entering the drill location will be conducted to a culvert system.

Maintain flat gradients in ditches to prevent surface erosion. If necessary, along the roadway ditches, provide drop structures to reduce velocities.

3.03 ENGINEERED CUTS

Cut slopes less than 15' in height shall not exceed 1 vertical on 1.5 horizontal. Slopes with heights greater than 15' should not exceed 1 vertical on 1.75 horizontal. Cut slopes higher than 30' shall be benched. Steeper slopes may be employed on a case-by-case basis 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.

The above requirements are general. Flatter slopes may be required where soil or rock conditions indicate. (For example, in certain locations where cuts are directly made on weak-weathered serpentine rock, the slopes should be made flatter, to compensate for the easy weathering and eroding rock.)

4.01 DRAINAGE AND EROSION CONTROLS

Road and location surfaces shall be sloped so as to direct drainage to the inside or up-slope direction. (The slope shall be approximately two feet per hundred feet.)

A drainage system designed in accordance with the Design Standards of the State of California, Division of Highways, shall be provided to adequately carry away water collected on the surface of the roads or drilling locations, as well as, water intercepted from upper slopes and natural drainage systems.

The above drainage system shall consist of ditches on the up-slope side of roads and on the perimeter of drilling locations. These ditches shall be sloped to drain on a gentle gradient and sand/cement filled bags shall be installed as energy breakers where required to prevent erosion. The drainage ditches shall be conducted to culverts; sized, designed and 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 will be extended to existing natural drainage areas.

Concurrently, with the placing and compacting of backfil on drill locations, corrugated culvert drainage structures shall shall be installed in accordance with the above standards. The discharge point of these culverts shall be carried well below the zone of existing erosion. At the discharge point, erosion, shall be prevented by constructing a headwall around the end of the culvert using sand/cement filled sand bags. The bags shall be laid single fashion to form an attractive and durable structure. Approximately 10' downstream from the discharge point, a low headwall shall be constructed of sand/cement filled sand bags laid single fashion to serve as a stilling basin. The discharge velocity over the low wier thus constructed, would be no greater than the original channel velocity.

5.01 DRILL SITE PAD AND ROAD SURFACES

Drill site pads and road surfaces shall be stabilized to improve traficability and reduce soil loss during rainfall runoff.

A 2' surface depth shall be provided and compacted in six to eight inch lifts. The material shall be moistened as required, and 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.

6.01 DRILL SITE DISPOSAL AREAS (SUMPS)

The disposal site is required to handle drilling wastes which are generated from drilling geothermal steam wells adjacent to the location.

The drilling waste disposal areas (sumps) will be provided with an impervious lining which will preclude the seepage or migration of any of the materials contained therein into the surrounding soil, down gradient surface water, or ground water.

A minimum free board of 3' shall be maintained in the waste sump.

Surface discharge from tributary areas shall not be discharged to the waste sump.

The sumps shall be constructed with baffels and clarifying ponds so as to allow for recycling of free water.

Good mud may be salvaged and used in other wells, to reduce the amount of mud in the waste sump.

Disposal areas are to be graded away from the drilling locations, so that the only rainwater that can accumulate in the sump, is that which falls directly on it.

The top of the sump shall be graded to prevent runoff induced erosion of the downhill face of the dike.

Water confinement barriers shall be protected and maintained to ensure their effectiveness.

There shall be no overflow from the waste sump, normally, the pump will have sufficient freeboard to accommodate increase due to rainfall. If the sump appears to be in jeopardy of overflowing, the water will be hauled to other disposal sumps in the area which have the capacity to hold water, or will be otherwise properly disposed of in an injection well, or by hauling to a qualified disposal area.

It is suggested that high pH, if present, can be reduced by not backfilling the sump immediately after the completion of the well. By exposing the sump to the atmosphere, evaporation will occur, consolidating the mud at the same time permitting it to react with the carbon dioxide of the air to form sodium carbonate which will result in a neutral pH.

Three alternative types of membrane liners are recommended for the sumps, depending on weather conditions and the

availability of materials. The slopes of these disposal areas should not exceed 1 on 1.75, and the bottom width should not be less than 5 feet, regardless of which type of lining is employed.

6.02 IMPERVIOUS SOIL LINING

The preferred type of lining, if weather conditions permit, is an impervious clay lining.

The advantages of the impervious clay lining are that it conforms to the sump shape; it is self healing; and, it is not subject to accidental rupture should pipe, tool, drill rods, be accidentally dropped into the sump, or should earthquake movements occur.

The sump location shall be thoroughly compacted to 95% of ASTM D-1557-70.

A 2' clay lining shall then be applied. The clay lining shall be placed in six inch layers; the soil should be moistened to optimum moisture content and compacted to at least 95% of ASTM D-1557-70. Tamping rollers or rubber-tired rollers may be used on the first three layers. The final six inch layer should be compacted by means of rubber-tired or smooth wheel rollers.

The permeability of the lining as placed shall not exceed $1x10^{-6}$ cm/sec. (Assuming that the average time to complete a well is 60 days, only a percolation depth of 0.17" would be accomplished, which is well within the 2' impervious depth.)

6.03 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 pozmix cement in the amount of approximately 10% by volume shall be added and thoroughly mixed into selected soils 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. Tamping rollers or rubber-tired rollers may be used on the first three layers. The final six inch layer should be compacted by means of rubber-tired or smooth wheel rollers.

The permeability of the lining as placed shall not exceed $1x10^{-6}$ cm/sec.

6.04 VINYL (PVC) MEMBRANE LINING

The sump area must be carefully compacted to present a smooth surface. Rocks, rock fragments, and other materials which might puncture the membrane must be removed.

A light sand or sand/cement fill, one to three inches in thickness may be applied to assist in proficing a smooth surface.

A vinyl membrane not less than 20 mils in thickness may be applied to assist in proficing a smooth surface. A vinyl membrane not less than 20 mils in thickness shall be applied. The vinyl will be prefabricated to meet the requirements of the individual ponds and will be packaged so that it may be unfolded into place without the necessity of pulling or dragging the membrane. The membrane shall be laid with sufficient slack to accomodate temperature changes.

A ditch approximately 12 inches deep shall be excavated at the perimeter of the sump.

After placement of the vinyl lining, a light 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.

7.01 DRILL SITE DISPOSAL AREA ABANDONMENT

Upon completion of drilling operations at drill site locations, waste containment areas 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 backfilled.

A two foot high compacted berm shall be installed between the sump area and the drill site location pad to prevent water from running off the pad on to the sump.

The surface of the disposal area shall be sloped to drain, graded for an attractive appearance, and revegetated with grasses and/or other woody plants.

APPENDIX B

Some familiarity with noise levels and related phenomena is assumed in this discussion. The A-weighting network which has become virtually the universal frequency filtering system in recent years for the analysis of environmental noise, is used throughout. This weighting network more or less approximates the ear's own filtering system. The lowest level that can be heard is approximately zero dBA, although seldom is any area quieter than about 30 dBA. A chart of noise sources and some associated levels is included for clarification, as Figure 15.

Noise levels generated by high velocity gas flows emerging from pipes (jets) is caused primarily by the turbulent mixing that occurs along the boundary between the high-velocity exhaust jet and the quiescent atmosphere. In the far field at about 40° from the jet axis, the acoustic intensity of the noise given off by the jet can be characterized by the following relationship:

$$I = \frac{k\, p^2\, u^8\, D^2}{4\, \pi\, a_o^5\, p_o\, R^2}$$

and the overall unweighted sound pressure level is:

$$OASPL = 10 \log \frac{k\, p^2\, u^8\, D^2}{(4 \times 10^{-9})\, \pi\, p_o\, a_o^5\, R^2}$$

where

- p = density of the gas in the flow
- u = velocity of the gas at the exit
- p_o = density of the gas at standard temperature and pressure
- a_o = velocity of sound in air
- D = diameter of the nozzle
- R = distance from the source to the receiver
- k = empirical constant, taken to be 1.2×10^{-5}

and all units are in the cgs system.

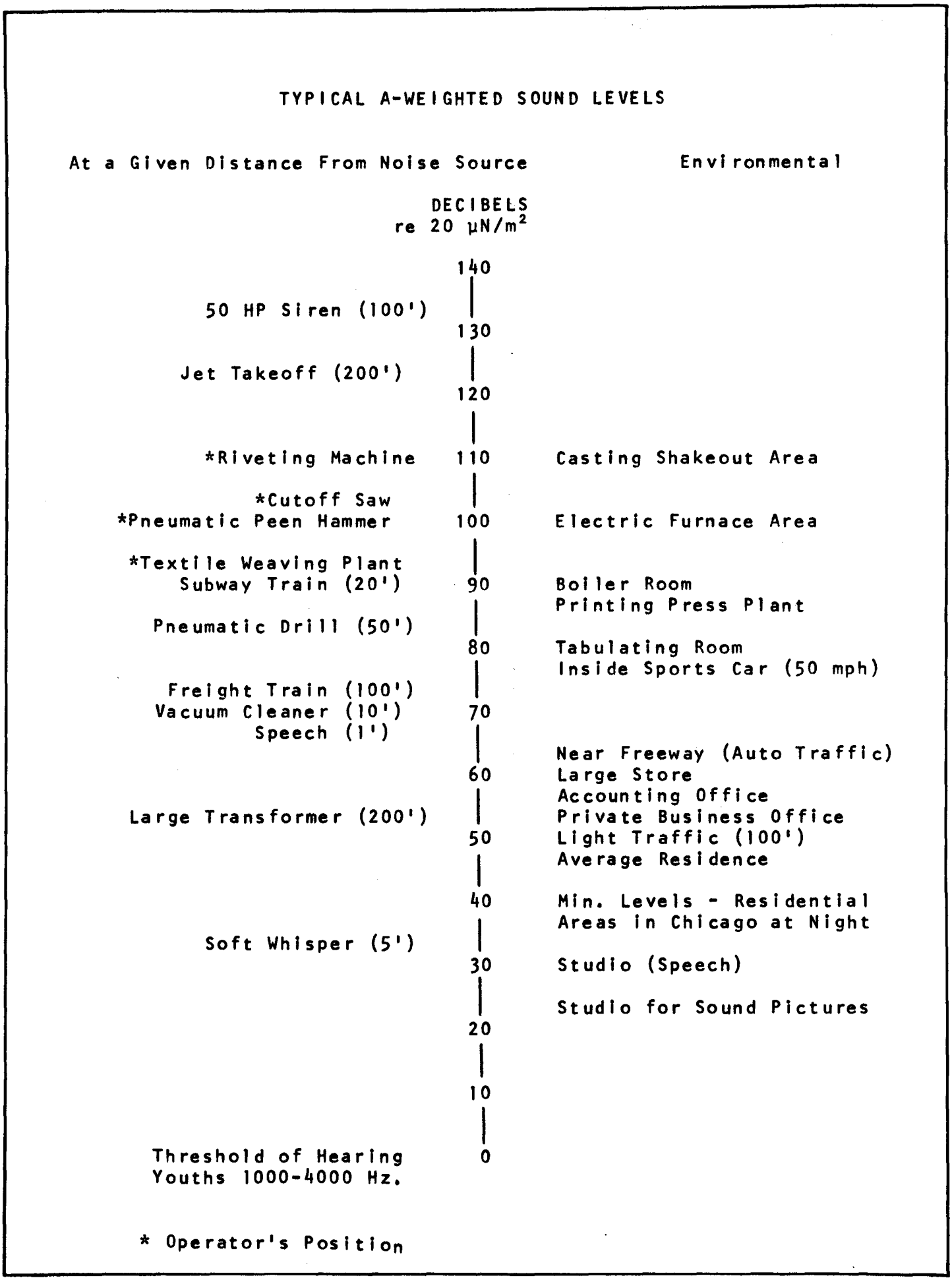
TYPICAL A-WEIGHTED SOUND LEVELS
At a Given Distance From Noise Source
Environmental
DECIBELS
re 20 μN/m²
140
50 HP Siren (100')
130
Jet Takeoff (200')
120
*Riveting Machine
110
Casting Shakeout Area
*Cutoff Saw
*Pneumatic Peen Hammer
100
Electric Furnace Area
*Textile Weaving Plant
Subway Train (20')
90
Boiler Room
Printing Press Plant
Pneumatic Drill (50')
80
Tabulating Room
Inside Sports Car (50 mph)
Freight Train (100')
Vacuum Cleaner (10')
70
Speech (1')
Near Freeway (Auto Traffic)
60
Large Store
Accounting Office
Large Transformer (200')
Private Business Office
50
Light Traffic (100')
Average Residence
40
Min. Levels - Residential
Areas in Chicago at Night
Soft Whisper (5')
30
Studio (Speech)
Studio for Sound Pictures
20
10
Threshold of Hearing
Youths 1000-4000 Hz.
0
* Operator's Position

FIGURE 15

This relationship yields a calculated overall sound pressure level at 50 feet of about 142 dB. At angles other than the 40° taken here the noise level is somewhat reduced due to the source directivity. The spectrum of the jet noise is shown in Figure 16. Using this spectrum, the overall A-weighted sound pressure level will be approximately 16 dB less than the overall sound level or 126 dBA. This agrees within a few dB with the measured values which are slightly higher and confirms the supposition that the flow velocity is near Mach 1 at the nozzle exit. The directivity pattern typical of jets of this type is shown in Figure 12. The primary region of noise generation is between 3 and 8 nozzle diameters downstream from the exit.

The attenuation of noise generated by jets is a subject which has received a great deal of attention due to recent research concentration on aircraft noise problems. Several approaches are used. Since there is an extremely strong dependence of noise on the flow velocity, slowing of the jet can be effective. However due to the very high pressures involved this can be a tricky process. With high velocity flows in pipes the smallest open area in the pipe system determines the maximum amount of gas which can be transferred through the pipe. The flow velocity will be Mach 1 or the local speed of sound at the smallest area when the ratio of the back pressure to atmospheric pressure is greater than about 2. Downstream from the smallest area the flow can accelerate or decelerate depending on the shape of the pipe, the flow conditions and a number of other factors. From the pressures which occur in the geothermal wells the velocities in the pipes during free venting are undoubtably supersonic and when a tapered diffuser is used the flow will contain a shock wave across which the velocity is abruptly decreased to Mach 1, probably near the diffuser exit. The diffuser presently in use is somewhat helpful in that it alters the characteristic spectrum of the noise by lowering the dominent frequency, which is dependent on the exit diameter, and thus it lowers the A-weighted sound pressure level. It does not however significantly decrease the flow velocity below Mach 1.

In order for the diffuser to be effective as a velocity decreaser, a converging-diverging nozzle, specifically designed for the flows and pressures present, should be placed ahead of it. This would allow the increasing area of the diffuser to effectively slow the flow velocity and reduce the noise output. The design of such a nozzle is complex and depends on the details of the geometry of the pipe and valves in use on the wells. The nozzle would also be subjected to constant wear which would erode the wall surfaces and change its characteristics. Due to instabilities in the flow the precise location of the shock wave is difficult to control and could relocate into the diffuser under certain conditions. The converging-diverging nozzle with a diffuser method of attenuation method, although it theoretically holds the greatest promise for noise reduction (50 dBA reduction is attainable), also has the highest uncertainty.

A combination of an ejector and shroud has also been effective in reducing jet noise. An ejector is a device which entrains air around

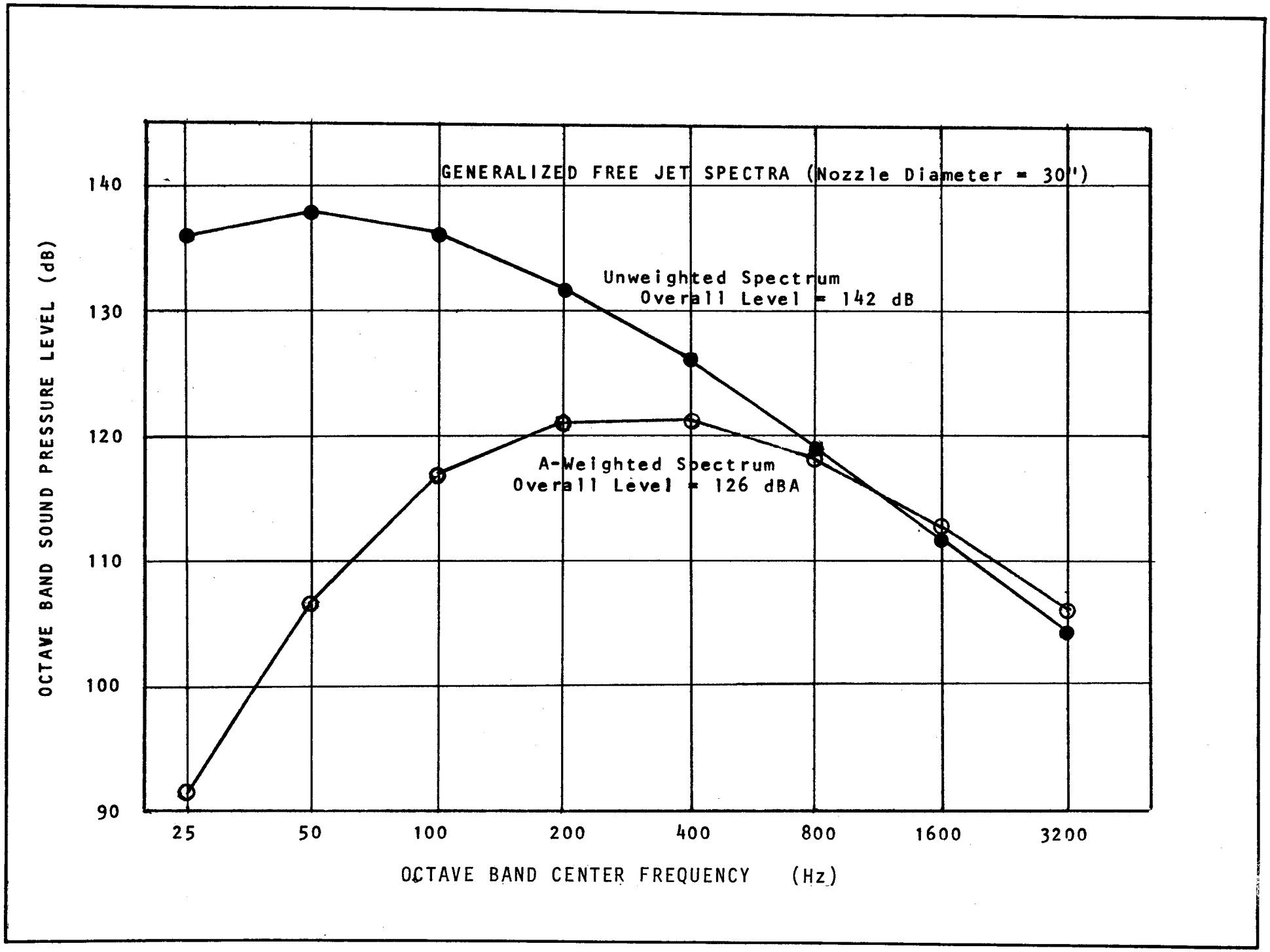
GENERALIZED FREE JET SPECTRA (Nozzle Diameter = 30')
Unweighted Spectrum
Overall Level = 142 dB
A-Weighted Spectrum
Overall Level = 126 dBA
OCTAVE BAND SOUND PRESSURE LEVEL (dB)
140
130
120
110
100
90
25
50
100
200
400
800
1600
3200
OCTAVE BAND CENTER FREQUENCY (Hz)

FIGURE 16

the jet and speeds the turbulent mixing process. A shroud is simply a barrier surrounding the mixing region. A typical example is shown in Figure 17. The diameter of the combination and shroud can be large in comparison to the jet diameter and thus would not be subjected to the high levels of wear which could effect a muffler. Attenuations of 20 dB or more have been achieved by using an ejector and shroud around the mixing region of a jet.

A ditch could also be utilized. The steam flow could be emitted below ground, 6 to 8 feet below grade for example, and attenuation would be available from the walls of the ditch. A ditch 50 or so feet long, covered over for the first 15 to 20 feet would provide a shield for the mixing region by using the absorbent properties of the earth to slow and expand the flow, thus attenuating the turbulent generated noise. Possible air pollution problems might occur due to blowing dust, however, the present practice of exhausting the flow close to the ground creates a similar situation. Approximately 15 dBA of attenuation could be achieved at 50 feet from the flow, however more than 25 dBA of attenuation might be expected in Anderson Springs or Verdant Vales, due to this method of containment.

DOUBLE EJECTOR AND SHROUD

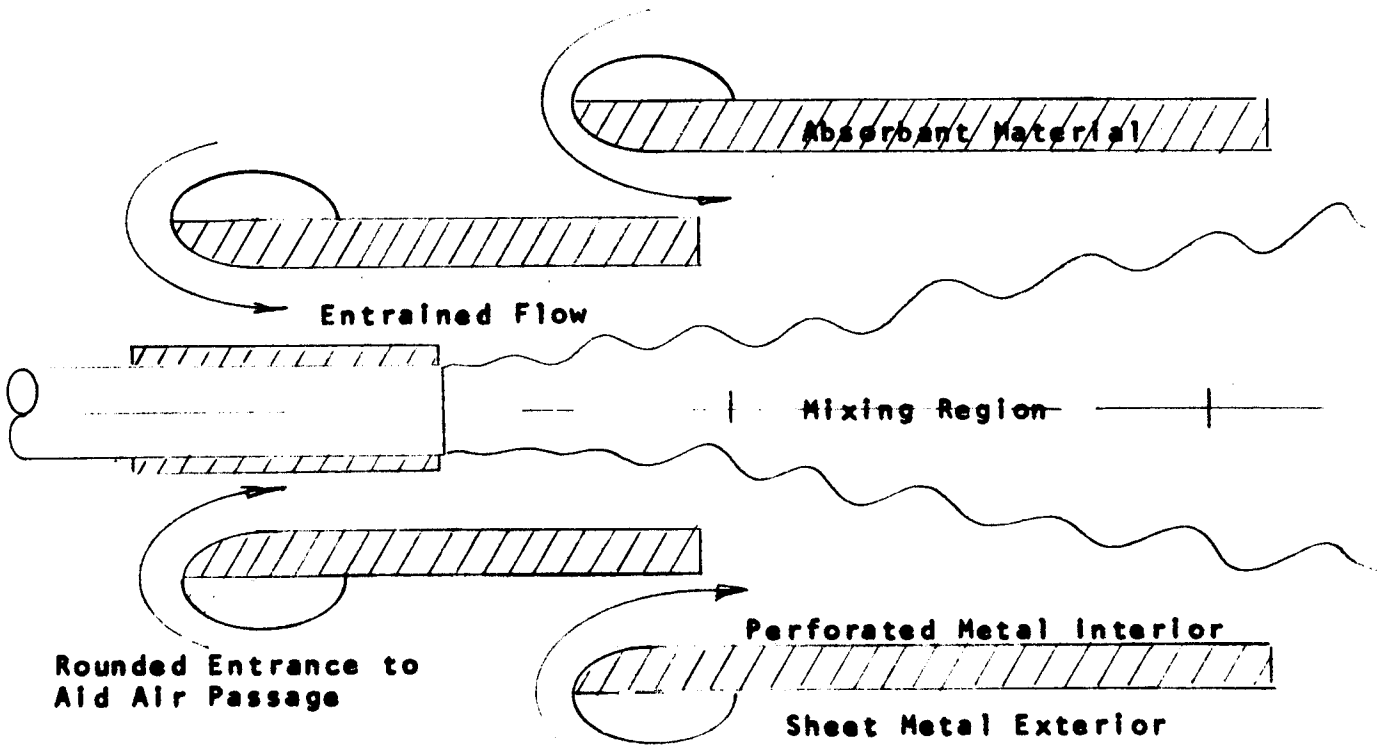

FIGURE 17

COUNTY OF LAKE

Department of Agriculture
5440 Live Oak Drive
Kelseyville, California 95451
(707) 279-4842

FILE COPY

MEMO

CHARLES L. GEOBLE
Agricultural Commissioner
Director of Weights & Measures
Animal Control Director
Air Pollution Director

January 13, 1975

To: Charles L. Geoble, APCD Director

From: _____
Fayne L. Tucker

Subject: Legal authority to act on excessive noise from Geothermal Development.

It appears that we have a conflict which requires resolving with respect to sound level readings and appropriate action to be taken by the APCD.

The limit of the allowable noise is set at 65 dBA at 1/2 mile from the source or 55 dBA in Anderson Springs. (A scale, Planning Commission Policy.)

Our County "Law" (policy) seems clear on this point. Our options appear to be few as long as this noise level is present if the APCD is the regulatory agency.

On January 7, 1975 sound readings were made at 0.52 miles from a well site. Nine of eleven low readings, (81%) exceeded the 65 dBA level and 11 of 11 high readings (100%) exceeded the legal noise limit. The average high reading was 72 dBA and the average low reading was 67 dBA. On January 10, 1975 the average low reading in Anderson Springs was 64 dBA and the average high was 78 dBA over 1 mile from the site.

As the situation stands now we have not offically warned Burmah Oil for the above mentioned infractions. My question is, should we write a notice of violation, if not a citation for excessive noise?

If the Burmah Oil Use Permit is now in effect, do we have the authority to act? If we do not have the authority to act, then should we continue to collect sound data?

cc Don Tompkins
Don Johnson

FLT:rt

APPENDIX C

Specific Site Revegetation Recommendations

Abel #1 Padsite, and the Access road into Abel #1:

Abel #1 padsite is located in a serpentine area. Adjacent vegetation includes cypress and dense chaparral. On the fill slope, 50% of the initial revegetation cover remains. Reseeding is needed on the cut bank slope above the padsite. The establishment of woody vegetation is not recommended, due to the serpentine influence. Manzanita seeds, with a pre-germination treatment, could be put into the seed mixture. Erosion check dams are needed in drainage ditches south and east of the padsite, and the culvert east of the padsite has almost washed out. Grass regeneration to the west of Abel #1 is doing well, and revegetation along the road is doing well, with a 60-80% ground cover. Gypsum and fertilizers used in B L M revegetation measures are recommended for reseeding on the site.

McKinley #1 Padsite

Good regeneration has occurred at this site. Reseeding is needed on the cut slope, however. Monterey and Ponderosa pines on the edge of the pad are growing well. Oak and Madrone trees on slopes below the pad reduce scenic impact. Erosion is severe, however, on the north side of the pad, across the fill slope. Reseeding is recommended for this unstable shale slope. Two erosion check dams are also recommended for drainage ditches on the east side of the pad. The cut bank requires additional visual screening, and is steep. Ponderosa pine or Coulter pine are recommended for planting on the talus slope at the base of the cut bank. Roadside regeneration along the road from McKinley #1 into Camp Verdant Vales is adequate, establishing 60-75% ground cover.

McKinley #2 Padsite

Grass regeneration at this site has been good, covering approximately 75% of the cut and fill slopes. Coulter pine is recommended for planting at the base of cut bank, and additional grass revegetation is recommended for talus slopes south of the padsite and the cut bank on the northwest side of the pad. Oats and ryegrass have established a good ground cover at this site; on the northern fill slopes almost 85% regeneration has occurred. Several additional Ponderosa or Coulter pine are recommended for planting north of the pad for visual screening.

Thorne 1, 2.

Grass cover on the cut banks surrounding this padsite is sparse, covering from 25 to 40% of the slopes. Reseeding on this site is recommended for this fall. The establishment of woody vegetation here is not recommended due to the hot exposure and little available soil moisture. Experiments with Coulter pine and Knobcone-Monterey cross are recommended to determine survival rates, however. When these trees from the on-site nursery are planted, newspaper or cardboard should be placed around the base to prevent grass competition. Chaparral is adjacent to the site; the use of manzanita seeds in the grass mixture is recommended. Ryegrass seems to do well here; use this species in heavy amounts in the seed mixture.

Thorne 3

Grasses from revegetation measures cover approximately 75% of the slopes here. Some erosion occurs below the padsite. Douglas-fir, Oak, and Madrone surround the site. Douglas-fir in the area provides excellent shade; moisture is more available and revegetation has a greater chance for survival. The access road into Thorne 3 has 45-50% revegetation cover and needs both reseeding and initial seeding where the road intersects the Socrates Mine Road. Douglas-fir seedlings are recommended for planting around the padsite and on all the cut and fill banks to hold soil, maintain scenic values, and assist the Douglas-fir forest in re-establishing itself.

Thorne 5

This is a fairly large pad area. Initial revegetation is required this fall. Some grasses have been seeded onto north-facing fill slopes previously, with 40% survival. Additional reseeding is recommended for this area. An intermittent riparian zone has been disturbed east of the padsite; in the future padsites should not be located next to these riparian zones. Coulter pines are recommended for planting on north-facing fill slopes, east-facing slopes near the Camp Verdant Vales road, and around the pad edge for screening. Manzanita seeds are recommended for addition to the seed mixture.

CA 956 #1

This padside is located in dense Chaparral and borders a Knobcone pine community. The cut and fill slopes, together with the sump cut and fill slopes, need initial revegetation. Grass was seeded onto the access road last year, with from 25 to 40% survival. Grass reseeding is recommended for access road slopes. The Knobcone-Monterey pine cross is recommended for planting around the pad and sump areas for visual screening. Knobcone pines are also recommended for planting on the entire sump area fill slope, to prevent erosion. Revegetation for this site is recommended for the Fall of 1975. Gully erosion is present at the base of the sump area fill slope; the culvert in this location should be extended into the edge of

McKinley #4 Padsite

An excellent ryegrass and oat ground cover has come up on the northeast fill slope. Over 90% regeneration occurred on the northeast fill slope. Less grass cover but good Ponderosa pine establishment has occurred on the smaller fill slope south of the pad, along the access road into Camp Verdant Vales. Grass cover has burned out on the cut slope west of the padsite; additional reseeding is recommended. Several buckbrush and manzanita species have begun to seed in at the base of the fill slope adjacent to this pad, where regeneration rates were high.

McKinley #5/Thorne 6 Padsite

Impacts from steam occur on the south side of the pad. Steam condensate should have been washed off vegetation following blooie-line venting. Cut and fill banks east of the padsite need revegetation, along with fill banks near the road. The soil is of fairly good quality, and Ponderosa or Coulter pine are recommended for planting on fill slopes and around the edge of the padsite. The reseeding of an open area west of the padsite and the road is recommended. A good job was done in this area of removing the brush, yet leaving Digger pine and Oak trees for visual screening.

McKinley #8 Padsite

A good grass cover with from 60 to 75% regeneration occurs on fill slopes near this padsite. Reseeding is recommended on the northeast fill slope where erosion is present on unstable soils. Ponderosa or Coulter pines are recommended for planting around the west, north and east sides of the pad for visual screening and topsoil preservation. Pines should also be planted 25 feet down the edge of the fill slope, as mentioned in the mitigation section, with 12 foot spacing. Erosion check dams are needed on north slope drainage ditches. Culverts below the padsite should extend to the sump area. After culverts are extended, rocks should be placed under the end of the culvert to further reduce gully erosion. Grass seeding is recommended for the talus slope at the base of the cut bank, to the south of the pad.

Murphy-McNeil-Lassiter Padsite (MML Padsite)

A rockslide to the south of the pad has covered one-half acre of Chaparral cover, and is an irreversible impact. More moisture is available at this site. Under the Douglas-fir canopy, Douglas fir seedlings are recommended for planting on the entire length of the northern fill slope for soil-holding purposes; spacing should be 6 feet. Grass revegetation has not grown well on the fill slope, nor on the sump area. The sump area needs to be covered with additional fill dirt and reseeded. Also an additional broadcast seeding is recommended for the fill slope to the north and the smaller fill slope to the east.

of the vegetation, and rocks should be placed under the end of the culvert. An erosion check dam should be constructed in the gully previously formed.

APPENDIX D

FLORA

Part A. DOMINANT SPECIES BY PLANT ASSOCIATION

Mixed Conifer-Hardwood

Common Name	Scientific Name
Douglas fir	Pseudotsuga menziessi
Sugar pine	Pinus lambertiana
Poison oak	Rhus diversiloba
Bigleaf maple	Acer macrophyllum
Black oak	Quercus kelloggii
Digger pine	Pinus sabiniana
Madrone	Arbutus menziessi
Ponderosa pine	Pinus ponderosa
Toyon	Heteromeles arbutifolia
Tanbark oak	Lithocarpus densiflora
Manzanita	Arctostaphylos spp.
Coffeeberry	Rhumnus californica
Redbud	Cercis occidentalis

Chaparral

Manzanita	Arctostaphylos spp.
Chamise	Adenostoma fasciculatum
Toyon	Heteromeles arbutifolia
California bay	Umbellularia californica
Coffeeberry	Rhamnus californica
Scrub oak	Quercus dumosa
Buck brush	Ceanothus cuneatus
Coyote bush	Baccharis pilularis
Poison oak	Rhus diversiloba
Digger pine	Pinus sabiniana

Riparian

Bigleaf maple	Acer macrophyllum
White alder	Alnus rhombifolia
California bay	Umbellularia californica
Canyon live oak	Quercus chrysolepis
Madrone	Arbutus menziesii
Douglas Fir	Pseudotsuga menziessi
Ponderosa pine	Pinus ponderosa

Redbud	Cercis occidentalis
Willow	Salix spp.
Box elder	Acer negundo
Wild grape	Vitus californica
Blackberry	Rubus vitifolius

Barren and Cleared Ground

Bur Clover	Medicago hispida
Oats	Avena spp.
Chess	Bromus spp.
Fescue	Festuca spp.
Filaree	Erodium spp.
Thistle	Cirsium spp.

Madrone-Oak

Madrone	Arbutus menziesii
Black Oak	Quercus kelloggii
Poison oak	Rhus diversiloba
Nutmeg	Torreya californica
California buckeye	Aesculus californica
Toyon	Heteromeles arbutifolia
Manzanita	Arctostaphylos spp.

Knobcone Pine

Knobcone pine	Pinus attenuata
California bay	Umbellularia californica
Manzanita	Arctystaphylos spp.

Cypress

Sargent's cypress	Cupressus sargentii
McNabb cypress	Cupressus macnabiana
Jepson's ceanothus	Ceanothus jepsonii
Knobcone pine (occasionally)	Pinus attenuata
Manzanita	Arctostaphylos spp.
Digger pine	Pinus sabiniana
Leather oak (on N. - facing slopes)	Quercus durata

Grassland - Oak

Black oak	Quercus kelloggii
Blue oak	Quercus douglasii
Bur clover	Medicago hispida
Chess	Bromus spp.
Fescue	Festuca spp.
Filaree	Erodium spp.
Thistle	Cirsium spp.
Interior live oak	Quercus wislezenii
White or Valley oak	Quercus lobata

Part B. FLORISTIC LIST OF PROJECT SITE VEGETATION

Grasses and Grasslike Plants

Annual bluegrass	Poa annua
Bermuda grass	Cynodon dactylon
Blue wildrye	Elymus glaucus
California fescue	Festuca californica
California medic	Melica californica
Dogtail	Cunosurus echinatus
Filaree	Erodium spp.
Foxtail fescue	Festuca megalura
Little quaking grass	Briza minor
Mediterranean barley	Hordeum hystrix
Medusa head	Elymus caput-medusas
Nitgrass	Gastridium ventricosum
Pine bluegrass	Poa scarbrella
Red brome	Bromus rubens
Blando brome (soft chess)	Bromus mollis
Ripgut grass	Bromus rigidus
Rush	Juncus spp.
Sedge	Carex spp.
Silver hairgrass	Aira caryophyllea
Slender oat	Avena barbata
Squirreltail	Scirpus spp.

Forbs

Bedstraw	Galium californicum
Brodia	Brodiaea pulchella
Brodia	Brodiaea laxa
Bur clover	Medicago hispida
California poppy	Eschscholzia californica
Common fennel	Foeniculum vulgare
Coyote mint	Monardella villosa
Death camas (star lily)	Zigadenus fremontii
Diogenes lantern	Calochortus amabilis
Fairy bells	Disporum hookeri var. trachyandrum

Forbs (cont.)

Fiddleneck	Amsinkia intermedia
Goldfields	Baeria chrysostoma
Gold Wire	Hypericum concinnum
Hedge nettle	Stachys spp.
Hedge parsley	Torilis nodosa
Iris	Iris douglass
Italian thistle	Carduus pycnocephalus
Leopold lily	Lilium pardalinum
Lupines	Lupinus spp. (including Lupinus sericatus)
Meadow Nemphila	Nemophila pedunculata
Milk wort	Polygola cornuta
Monkey flower	Mimulus gattatus
Monkey flower	Mimulus spp.
Mule's ear	Wyethia glabra
Mullein	Verbascum thapsis
Napa thistle	Centaurea militensis
Owl's clover	Orthocarpus spp.
Popcorn flower	Plagiobothrys spp.
Redwood pentstemon	Pentstemon corymbosus
Rein orchid	Habenaria elegans
Scarlet monkey flower	Mimulus cardinalis
Smooth car-ear	Hypochoeris glabra
Soap plant	Chlorogalum pomeridianum
True clovers	Trifolium spp.
Turkey mullein	Eremocarpus setigerus
Wintergreen	Pyrola aphylla
Wolly indian paintbrush	Castilleja foliolosa
Wolly sunflower	Eriophylum lanatum

Shrubs

Blackberry	Rubus vitifolius
Buckbrush	Ceanothus cuneatus
Buckwheat	Eriogenium spp.
Bush monkeyflower	Pipalcus aurantiacus
Bush poppy	Dendromecon rigida
Chamise	Adenostoma fasciculatum
Chaparral honeysuckle	Lonicera interrupta
Chaparral pea	Pickeringia montana
Cliff brake	Pellaea spp.
Coffeeberry	Rhamnus californica
Coyote brush	Baccharis pilularis
Deer brush	Ceanothus integerrimus
Jepson's ceanothus	Ceanothus jepsonii
Jim brush	Ceanothus soredatus
Manzanita	Arctostaphylos spp.
Poison oak	Rhus diversiloba
Redberry	Rhamnus crocea
Redbud	Cercis occidentalis
Scrub chinquapin	Castanopsis chrysophylla
Silk tassel bush	Garrya eliptica

Shrubs (cont.)

Toyon	Photinia arbutifolia
Victor's gooseberry	Ribes victoris
Virgin's bower	Clematis lasiantha
Wavyleaf ceanothus	Ceanothus foliosus
Western mountain mahogany	Cercocarpus betuloides
Wild rose	Rosea spp.
Wild grape	Vitis californica
Yerba santa	Eriodictyon californicum

Trees

Bigleaf maple	Acer macrophyllum
Black oak	Quercus kelloggii
Blue oak	Quercus douglasii
Box elder	Acer negundo
California buckeye	Aesculus californica
California bay (laurel)	Umbellularia californica
Digger pine	Pinus sabiniana
Douglas fir	Pseudotsuga menziessi
Incense cedar	Libocedrus decurrens
Interior live oak	Quercus wislezenii
Knobcone pine	Pinus attenuata
Leather Oak	Quercus durata
Madrone	Arbutus menziesii
McNabb cypress	Cupressus machabiana
Nutmeg	Torreya californica
Pacific dogwood	Cornus nuttallii
Ponderosa pine	Pinus ponderosa
Sargent's cypress	Cupressus sargentii
Scrub oak	Quercus dumosa
Shrubby canyon live oak	Quercus chrysolepis
Shrub interior live oak	Quercus wislizenii var. fructescens
Sugar pine	Pinus lambertiana
Tanbark oak	Lithocarpus densiflora
Valley oak (White oak)	Quercus lobata
White alder	Alnus Thombifolia
Willow	Salix spp.

Ferns

Bracken fern	Pteridium aquilinum
Goldenback fern	Pityrogramma spp.
Lip fern	Cheilanthes spp.
Maidenhair fern	Adiantum jordanii
Polypody	Polypodium californicum
Sword fern	Polystichum munitum
Woodwardia fern	Woodwardia chamissoi

APPENDIX E

LIST OF POSSIBLE RARE AND ENDANGERED VASCULAR PLANTS

Species	Elevation
Amaryllidaceae	
Brodiaea coronaria spp. rosea	below 5000'
Compositae	
Lasthenia burkei (possibly extinct)	below 500'
Crassulaceae	
Parvisedum leiocarpum	near 1300'
Parvisedum pentandrum	800' to 2500'
Cruciferae	
Streptanthus morrisonii var.	1500'-4,000'
Gramineae	
Orcuttia tenuis	about 1500'
Panicum thermale	1000' - 1800'
Pleuropogen davvi	below 2,000'
Leguminosae	
Astragalus clarianus	300' - 500'
*Lupinus sericatus	2,000' - 4,000'
Liliaceae	
Calochortus pulchellus	above 700'
Erythronium helenae	1500' - 2200'
Fritillaria glauca	2,000' - 7,000'
Fritillaria liliacea	1000' - 2200'
Fritillaria pluriflora	below 1500'
Fritillaria phaeanthera	1000' - 2500'
Fritillaria purdyi	1400' - 9000'

*Identified in project area

Linaceae	
Hesperolinon adenophyllum	1500' - 4500'
Hesperolinon bicarpellatum	1200' - 1500'
Hesperolinon drymarioides	2300' - 2700'
Polemoniaceae	
Eriastrum brandegeae	1400' - 2500'
Navarretia pauciflora	1500' - 2500'
Navarretia plieantha	1500' - 2500'
Polygonaceae	
Eriogonum caninum	1000' - 2200'
Pyrolaceae	
Pityopus californicus	1000' - 5000'
Scrophulariaceae	
Penstemon filiformis	
Umbelliferae	
Lomatium repostum	

Species from Inventory of Rare, Endangered, and Possibly Extinct Vascular Plants of California, California Native Plant Society. (Information as of February 1974).

Elevation range from A California Flora, by P.A. Munz and D.D. Keck, 1968.

APPENDIX F

FAUNA

Amphibians

Common Name	Scientific Name
Pacific giant salamander	Dicamptodon ensatus
Tiger salamander	Ambystoma tigrinum
Rough-skinned newt	Taricha granlosa
Red-bellied newt	Taricha rivularis
Ensatina	Ensatina eschscholtzi
California newt	Taricha torosa
California slender salamander	Batrachoseps attenuatus
Arboreal salamander	Aneides lugubris
Black salamander	Aneides flavipunctatus
Western spadefoot toad	Scaphiopus hammondi
Western toad	Bufo boreas
Pacific treefrog	Hyla regilla
California red-legged frog	Rana aurora
Foothill yellow-legged frog	Rana boylei
Bullfrog	Rana catesbeiana

Reptiles

Western pond turtle	Clemmys marmorata
Northwestern fence lizard	Sceloporus occidentalis
Western skink	Eumeces skiltonianus
Foothill alligator lizard	Gerrhonotus milticarinatus
California whiptail	Cnemidophorus tigris
California horned lizard	Phrynosoma coronatum
Northern sagebrush lizard	Sceloporum graciosus
Pacific rubber boa	Charina bottae
Pacific ringneck snake	Diadophis punctatus
Sharp-tailed snake	Contia tenuis
Pacific gopher snake	Pituophis melanoleucus
California mountain kingsnake	Lampropeltis zonata
Common kingsnake	Lampropeltis getulus
Common garter snake	Thamnophis sirtalis
Western garter snake	Thamnophis elegans
Aquatic garter snake	Thamnophis couchi
Pacific rattlesnake	Crotalus viridis
California striped racer	Masticophis Lateralis
Western yellow-bellied racer	Coluber constrictor
California night snake	Hypsiglena torquata

Mammals

Coyote	Canis latrans
Gray fox	Urocyon cinereoargen teus
House mouse	Mus musculus
Muskrat	Ondatra zibethica
California meadow mouse	Microtus californicus
Dusky-footed woodrat	Neotoma fuscipes
Deer mouse	Peromyscuc maniculatus
Pinyon mouse	Peromyscus truei
Brush mouse	Peromyscuc boylii
Western harvest mouse	Reithrodontomys megalotis
Heermann kangaroo rat	Dipododomys heermanni
Botta pocket gopher	Thomomys bottae
Western gray squirrel	Sciurus griseus
Sonoma chipmunk	Eutamias sonomae
Beechey ground squirrel	Otospermophilus beecheyi
Brush rabbit	Sylvilagus bachmani
Audubon cottontail	Sylvilagus audubonii
Black-tailed hare	Lepus californicus
Brazilian free-tailed bat	Tadarida brasiliensis
Lump-nosed bat	Plecotus townsendii
Pallid bat	Antrozous pallidus
Big brown bat	Eptesicus fuscus
Red bat	Lasiurus borealis
Hoary bat	Lasiurus cinereus
Silvery-haired bat	Lasionycteris noctivagans
Yuma bat	Myotis yumanensis
Long-eared bat	Myotis evotis
Hairy-winged bat	Myotis volans
California bat	Myotis californicus
Fringed bat	Myotis thysanodes
Little brown bat	Myotis lucifugus
Western mole	Scapanus latimanus
Trowbridge shrew	Sorex trowbridgii
Ornate shrew	Sorex ornatus
Pacific shrew	Sorex pacificus
Opossum	Didelphis marsupialis
Broad-handed mole	Scapanus latimanus
Shrew-mole	Neurotrichus gibbsi
Townsend chipmunk	Eutamias townsendi
Douglas squirrel	Tamiasciurus douglasi
Porcupine	Erethizon dorsatum
Black bear	Euarctos americanus
Raccoon	Procyon lotor
Ringtail cat	Bassariscus astutus
Mink	Mustela vison
Long-tailed weasel	Mustela frenata
Striped skunk	Mephitis mephitis
Spotted skunk	Spilogale putoris
Badger	Taxidea taxus
Bobcat	Lynx rufus
Mountain lion	Felix concolor

Mammals, (Continued)

Black-tailed deer	Odocoileus hemionus columbianus
Vagrant Shrew	Sorex vagrans
Pacific mole	Scapanus orarius
Western big-eared bat	Plecotus townsendi
Fisher	Martes pennanti
Shorttail weasel	Mustela erminea
California vole	Mycrotus californicus
California redback vole	Clethrionomys occidentalis
Wild boar	Sus scrofa
Tree phenacomys	Phenaromys longicaudus
California ground squirrel	Citellus beecheyi

BIRDS

Abundance:

C - Common
U - Uncommon
V - Visitor
SV - Summer Visitor
WV - Winter Visitor
R - Rare
E - Endangered

Common Name	Scientific Name	Abundance
Peregrine falcon	Falco peregrinus	E
Prairie falcon	Falco mexicanus	C
Turkey vulture	Cathartes aura	C
Sharp-shinned hawk	Accipiter striatus	C
Cooper's hawk	Accipiter cooperii	C
Sparrow hawk	Falco sparvarius	C
Swainson's hawk	Buteo swainsoni	V
Red-tailed hawk	Buteo jamaicensis	C
Red-shouldered hawk (red-bellied)	Bueto lineatus	C
Rough-legged hawk	Buteo lagopus	R
Ferruginous hawk	Buteo regalis	R
Golden Eagle	Aquila chrysaetos	U
Bald Eagle	Haliaeetus leucocephalus leucocephalus	E
Osprey	Pandion haliaetus carolinensis	U/SV
American kestrel	Falco sparverius	C
California quail	Lophortyx californicus	C
Mountain quail	Oreortyx pictus	C
Snowy plover	Charadrius alexandrinus	WV
Blue grouse	Dendragapus obscurus	SV
Roadrunner	Geococcyx californianus	V
Ring-necked pheasant	Phasianus colchicus	C
Band-tailed pigeon	Columba fasciata	C
Mourning dove	Zenaidura macroura	C
Barn owl	Tyto alba	C
Saw-whet owl	Aegolius acadicus	SV
Screech owl	Otus asio	C
Great-horned owl	Bubo virginianus	C
Pygmy owl	Glaucidium gnoma	R
Western burrowing owl	Speotyto cunicularia hypugaea	C
Long-eared owl	Asio otus	R
Anna's hummingbird	Calypte anna	C
Black-chipped hummingbird	Archilochus alexandri	SV
Clark's nutcracker	Nucifraga columbiana	C

Common Name	Scientific Name	Abundance
Rufous hummingbird	Selasphorus rufus	V
Allen's hummingbird	Selasphorus sasin	SV
Belted kingfisher	Megaceryle alcyon	C
Common flicker	Colaptes auratus	C
Pileated woodpecker	Dryocopus pileatus	R
Acorn woodpecker	Melanerpes formicivorus	C
Yellow-bellied sapsucker	Sphyrapicus varius	C
Hairy woodpecker	Dendrocopos villosus	C
Downy woodpecker	Dendrocopos pubescens	C
Nuttall's woodpecker	Dendrocopos nuttallii	C
Western kingbird	Tyrannus verticalis	C
Ash-throated flycatcher	Myiarchus cinerascens	C/SV
Hammond's flycatcher	Empidonax hammondii	SV
Traill's flycatcher	Empidonax trallii	C
Olive-sided flycatcher	Nuttallornis borealis	SV
Vaux's swift	Chaetura vauxi	SV
Black-billed magpie	Pica pica	C
Black phoebe	Sayornis nigricans	C
Say's phoebe	Sayornis saya	C
Western flycatcher	Empidonax difficilis	SV
Western wood pewee	Contopus sordidulus	SV
Horned lark	Eremophila alpestris	R
Violet-green swallow	Tachycineta thalassina	SV
Tree swallow	Iridoprocne bicolor	SV
Rough-winged swallow	Stelgidopteryx ruficollis	SV
Barn swallow	Hirundo rustica	SV
Cliff swallow	Petrochelidon pyrrhonota	SV
Purple martin	Progne subis	R
Stellar's jay	Cyanocitta stelleri	C
Scrub jay	Aphelocoma coerulescens	C
Common raven	Corvus corax	C
Common crow	Corvus brachyrhynchos	C
Killdeer	Charadrius vociferous	C
Phainopepla	Phainopopla nitens	U
House finch	Carpodacus cassinii	C
Pine siskin	Spinus pinus	C
Red crossbill	Loxia curvirostra	C
Oregon junco	Junco Oreganus	C
Chestnut-backed chickadee	Parus rufescens	C
Plain titmouse	Parus inornatus	C
White-breasted nuthatch	Sitta carolinensis	C
Red breasted nuthatch	Sitta canadensis	WV
Pygmy nuthatch	Sitta pygamea	R
Brown creeper	Certhia familiaris	C
Common bushtit	Psaltriparus minimus	C
Wrentit	Chamaea fasciata	C

Dipper (Water ouzel)	Cinclus mexicanus	X
House wren	Troglodytes aedon	R
Winter wren	Troglodytes troglodytes	C
Bewick's wren	Thryomanes bewickii	C
Mockingbird	Mimus polyglottos	C
California thrasher	Toxostoma redivivum	R
American robin	Turdus migratorius	C
Varied thrush	Ixoreus naevius	WV
Hermit thrush	Hylocichla guttata	WV
Swainson's thrush	Hylocichla ustulata	WV
Western bluebird	Sialia mexicana	C
Golden-crowned kinglet (Ruby-crowned)	Regulus satrapa	WV
Water pipit	Anthus spinoletta	U
Cedar waxwing	Bombycilla cedrorum	WV
Loggerhead shrike	Lanius ludovicianus	C
Starling	Sturnus vulgaris	C
Hutton's vireo	Vireo huttoni	WV
Solitary vireo	Vireo solitarius	SV
Yellow-rumped warbler	Dendroica coronata	WV
Audubon's warbler	Dendroica auduboni	C
Black-throated gray warbler	Dendroica nigrescens	R
Townsend's warbler	Dendroica townsendi	WV
Hermit warbler	Dendroica occedentalis	R
MacGillivray's warbler	Oporornis tolmiei	WV
Common yellowthroat	Geothlypis trichas	C
Yellow-breasted chat	Icteria virens	SV
Wilson's warbler	Wilsonia pusilla	SV
House sparrow	Passer domesticus	C
Western meadowlark	Sturnella neglecta	C
Red-winged blackbird	Agelaius phoeniceus	U
Northern oriole (Bullock's)	Icterus bullockii	SV
Brewer's blackbird	Euphagus cyanocephalus	C
Brown headed cowbird	Molothrus ater	SV
Western tanager	Piranga ludoviciana	R
Black-headed grosbeak	Pheuticus melanocephalus	SV
Lazuli bunting	Passerina amoena	SV
Purple finch	Carpodacus purpureus	R
American goldfinch	Spinus tristis	SV
Lesser goldfinch	Spinus psaltria	C
Rufus-sided towhee	Pipilo erythrophthalmus	C
Brown towhee	Pipilo fuscus	C
Sage sparrow	Amphispiza belli	SV
Savannah sparrow	Passerculus sandwichensis	C
Lark sparrow	Chondestes grammacus	C
Slate-colored junco	Junco hyemalis	C
Chipping sparrow	Spizella passerina	R

White-crowned sparrow	Zonotrichia leucophrys	WV
Golden-crowned sparrow	Zonotrichia atricapilla	WV
White-throated sparrow	Zonotrichia albicollis	R
Fox sparrow	Passerella iliaca	WV
Lincoln's sparrow	Melospiza lincolnii	WV
Song sparrow	Melospiza melodia	C

APPENDIX G

Major Vegetative Species and Wildlife Use

Wildlife Habitat Types

R - Riparian
G - Grassland-Oaks
CH - Chaparral
McH - Mixed Conifer-Hardwood and Mixed Conifer

Vegetation Species (Common Name)	Wildlife Habitat Type	Wildlife Use
California bay (laurel)	R, Ch	Deer browse on young sprouts
Chamise	Ch	Chaparral cover, and deer browse
Chaparral pea	Ch, McH	Deer browse
Deer brush	Ch, McH	Preferred deer browse
Digger pine	Ch, McH	Seeds for squirrels
Douglas fir	R, McH	Cover; deer browse on reproduction trees
Filaree	R, G, McH	Seed source for birds and small mammals, also preferred deer forage
Victor's gooseberry	R	Berries for quail, small birds
Interior live oak	G, Ch, McH	Bird nesting and acorns for deer and squirrels
Knobcone pine	R, Ch, McH	Cover and seeds for upland game
Leather oak	G, Ch, McH	Deer Browse
Madrone	G, Ch, McH	Cover
Manzanita	G, Ch, McH	Deer browse, cover; berries are food for bear, pigeons, and small mammals

Major Vegetative Species and Wildlife Use

Vegetation Species (Common Name)	Wildlife Habitat Type	Wildlife Use
Poison oak	R, G, Ch, McH	Deer browse; cover
Redberry	Ch	Deer browse, berries used by quail, small mammals, and pigeons
Red brome	G, McH	Deer forage in spring, seeds used by upland game birds, songbirds, and small mammals
Ripgut brome	G, McH	Same as Red brome
Rushes	R	Forage for deer in summer, nesting and breeding use by waterfowl
Rose clover	R, G, McH	Foliage browsed by deer and upland game; seeds used by quail
Scrub oak	Ch, McH	Cover for all species and deer forage
Sedges	R	Summer deer forage, waterfowl food, nesting, and resting/shelter cover
Silk tassel	Ch, McH	Preferred deer browse
Toyon	Ch, McH	Cover, and berries used by upland game birds and bear
Turkey mullein	G, McH	Seeds preferred by quail, songbirds, and doves
Buckbrush and Wavyleaf ceanothus	Ch, McH	Preferred deer browse
White or Valley oak	R, G, McH	Acorns used by deer and squirrels; bird nesting
Wild Grape	R	Quail food; cover

Vegetation Species (Common Name)	Wildlife Habitat Type	Wildlife Use
Wild Oats	R, G, McH	Seeds for upland game and songbirds
Wild Rose	R, McH	Upland game food and cover
Willow	R	Deer browse; buds and catkins valuable to upland game. Foliage and bark used by small mammals
Yerba Santa	Ch, McH	Deer browse on new sprouts, also cover

WILDLIFE OBSERVED AT THE CASTLE ROCK SPRINGS PROJECT SITE

APPENDIX H

Mammals

Common Name	Scientific Name
Black-tailed deer	Odocoileus hemionus columbianas
Black-tailed hare	Lepus californicus
Brush rabbit	Sylvilagus bachmani
Grey fox	Urocyon cinereoargenteu
Striped skunk	Mephitis mephitis
Western grey squirrel	Sciurus griseus
Beechey ground squirrel	Otospermophilus beecheyi
Raccoon	Procyon lotor
Botta pocket gopher	Thomomys bottae
Big brown bat	Eptesicus fuscus
Deer mouse	Peromyscuc maniculatus

Amphibians and Reptiles

Common garter snake	Thamnophis sirtalis
Pacific rattlesnake	Crotalus viridis
Pacific tree frog	Hyla regilla
Bullfrog	Rana catesbeiana
Western skink	Eumeces skiltonianus
California slender salamander	Batrachoseps attenuatus
Red-bellied newt	Taricha rivularis
Northwestern fence lizard	Sceloporus occidentalis

Birds

Peregrine falcon	Falco peregrinus
Sparrow hawk	Falco sparvarius
Red-tailed hawk	Bueto jamaicensis
Mountain quail	Oreortyx pictus
Califomia quail	Lophortyx californicus
Mourning dove	Zenaidura macroura
Common flicker	Colaptes aurates
Turkey vulture	Cathartes aura
Scrub jay	Aphelocoma coerulescens
Stellar's jay	Cyanocitta stelleri
Common bushtit	Psaltriparus minimus
Downy woodpecker	Dendrocopes pubescens
Tree swallow	Iridoprocne bicolor
Oregon junco	Junco oreganus
Killdeer	Charadrius vociferous
Black-headed grosbeak	Pheuticus melanocephalus
American robin	Turdus migratorius
Brown towhee	Pipilo fuscus

APPENDIX I

CHEMICAL ANALYSES

Gunning Creek Upstream Socrates Mine Road Bridge

Castle Rock - Hot Springs Drainage above Subdivision

Bear Canyon Creek Before Confluence with Anderson Creek

Anderson Creek Before Confluence with Putah Creek

Gunning Creek Upstream Socrates Mine Road

Castle Rock Creek 500 ft. Upstream Anderson Creek

Anderson Creek at Confluence with Putah Creek

Bear Canyon Creek 20 ft. Upstream from Anderson Creek

Prepared by Brelje and Race Laboratories

August, 1975

BRELJE AND RACE

LABORATORIES 425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIFORNIA 95403 TELEPHONE (707) 544-8807

August 26, 1975

Burmah Oil Corporation
1100 C Coddingtown Center
Santa Rosa, Calif. 95406

Attention: George Frye

Gentlemen:

The results of the analyses on the samples collected on August 12 and 20, 1975, from the Anderson Springs Geothermal well area in Lake County are attached. The unnamed drainage creek on Socrates Mine Road was dry when the other samples were taken.

Very truly yours,

BRELJE AND RACE LABORATORIES

J. Amundsen by G.E.D.

J. AMUNDSEN

JA:ah

LABORATORIES

CHEMICAL ANALYSIS

FOR: Burmah Oil Corporation

ADDRESS 1100 C Coddingtown Center

CITY & STATE Santa Rosa, Calif. 95406

SAMPLE SOURCE Gunning Creek Upstream Socrates Mine Road Bridge

DATE-TIME COLLECTED 8-12-75

COLLECTED BY Brelje & Race Labs

MAJOR ANIONS	MG/L*	ME/L**	DETERMINATION	MG/L*	DETERMINATION	MG/L*
SO4 - Sulfate	<0.5		Alkalinity - Total	41.	F-Fluoride	0.08
Cl - Chloride	2.5		Calcium Hardness CaCO3	18.	B-Boron	<0.01
HCO3 - Bicarbonate	50.		Magnesium Hardness CaCO3	20.	Al-Aluminum	0.05
CO3 - Carbonate	0		Total Hardness CaCO3	38.	Mn-Manganese	<0.05
NO3 - Nitrate	<0.01		Total Dissolved Solids 180°C	63.	Fe-Iron	0.03
			Total Suspended Matter	<1.0		
TOTAL ME/L**					Phenol	
MAJOR CATIONS					Grease & Oil	<1.0
Ca - Calcium	7.2					
Mg - Magnesium	4.9				Heavy Metals (As Group)	
			Turbidity (Turbidity Units)	0.30 FTU	ABS	
Na - Sodium	2.1				Hg-Mercury	<1.0 µg/l
K - Potassium	<1.0		Hydrogen Ion Concentrate (pH)	7.4		
TOTAL ME/L**			Sp. Cond.-Micromhos 25°C	75		

* Milligrams Per Liter
** Milliequivalents Per Liter

Included in Standard Mineral Analysis

COMMENTS:

WORK AUTHORIZED Burmah Oil Corporation

SUPPLY OWNED BY

ANALYSIS NO. 875-4406

DATE COMPLETED 8-22-75

ANALYST J. Amundson by D.D.

LABORATORIES

CHEMICAL ANALYSIS

FOR: Burmah Oil Corporation

ADDRESS 1100 C Coddingtown Center

CITY & STATE Santa Rosa, Calif. 95406

SAMPLE SOURCE Castle Rock - Hot Spring Drainage above Subdivision

DATE-TIME COLLECTED 8-12-75

COLLECTED BY Brelje & Race Labs

MAJOR ANIONS	MG/L*	ME/L**	DETERMINATION	MG/L*	DETERMINATION	MG/L*
SO4 - Sulfate	160.		Alkalinity - Total	280	F-Fluoride	0.20
Cl - Chloride	1.6		Calcium Hardness CaCO3	150	B-Boron	0.37
HCO3 - Bicarbonate	340.		Magnesium Hardness CaCO3	180	Al-Aluminum	0.03
CO3 - Carbonate	0		Total Hardness CaCO3	330	Mn-Manganese	0.10
NO3 - Nitrate	0.33		Total Dissolved Solids 180°C	560	Fe-Iron	0.23
			Total Suspended Matter	<1.0		
TOTAL ME/L**					Phenol	
MAJOR CATIONS					Grease & Oil	<1.0
Ca - Calcium	60.					
Mg - Magnesium	44.				Heavy Metals (As Group)	
			Turbidity (Turbidity Units)	0.40 FTU	ABS	
Na - Sodium	29.				Hg-Mercury	4.5 µg/l
K - Potassium	25.		Hydrogen Ion Concentrate (pH)	7.8		
TOTAL ME/L**			Sp. Cond.-Micromhos 25°C	880		

* Milligrams Per Liter
** Milliequivalents Per Liter

Included in Standard Mineral Analysis

COMMENTS:

WORK AUTHORIZED Burmah Oil Corporation

SUPPLY OWNED BY

ANALYSIS NO. 875-4405

DATE COMPLETED 8-22-75

ANALYST J. Amundson by S.E.D.

LABORATORIES

CHEMICAL ANALYSIS

FOR: Burmah Oil Corporation

ADDRESS 1100 C Coddingtown Center

CITY & STATE Santa Rosa, Calif. 95406

SAMPLE SOURCE Bear Canyon Creek Before Confluence with Anderson Creek

DATE-TIME COLLECTED 8-12-75

COLLECTED BY Brelje & Race Labs

MAJOR ANIONS	MG/L*	ME/L**	DETERMINATION	MG/L*	DETERMINATION	MG/L*
SO4 - Sulfate	3.5		Alkalinity - Total	130	F-Fluoride	0.07
Cl - Chloride	2.0		Calcium Hardness CaCO3	48	B-Boron	0.05
HCO3 - Bicarbonate	160.		Magnesium Hardness CaCO3	82	Al-Aluminum	0.01
CO3 - Carbonate	0		Total Hardness CaCO3	130	Mn-Manganese	<0.05
NO3 - Nitrate	<0.01		Total Dissolved Solids 180°C	120	Fe-Iron	<0.02
			Total Suspended Matter	<1.0		
TOTAL ME/L**					Phenol	
MAJOR CATIONS					Grease & Oil	<1.0
Ca - Calcium	19.					
Mg - Magnesium	20.				Heavy Metals (As Group)	
			Turbidity (Turbidity Units)	0.25 FTU	ABS	
Na - Sodium	6.1				Hg- Mercury	1.5 µg/l
K - Potassium	<1.0		Hydrogen Ion Concentrate (pH)	7.6		
TOTAL ME/L**			Sp. Cond.-Micromhos 25°C	250		

* Milligrams Per Liter
** Milliequivalents Per Liter

Included in Standard Mineral Analysis

COMMENTS:

WORK AUTHORIZED Burmah Oil Corporation

SUPPLY OWNED BY

ANALYSIS NO. 875-4404

DATE COMPLETED 8-22-75

ANALYST J. Amundson by A.E.D.

LABORATORIES

CHEMICAL ANALYSIS

FOR: Burmah Oil Corporation

ADDRESS 1100 C Coddingtown Center

CITY & STATE Santa Rosa, Calif. 95406

SAMPLE SOURCE Anderson Creek Before Confluence with Putah Creek

DATE-TIME COLLECTED 8-12-75

COLLECTED BY Brelje & Race Labs

MAJOR ANIONS	MG/L*	ME/L**	DETERMINATION	MG/L*	DETERMINATION	MG/L*
SO4 - Sulfate	3.3		Alkalinity - Total	60.	F-Fluoride	<0.02
Cl - Chloride	3.5		Calcium Hardness CaCO3	28.	B-Boron	0.03
HCO3 - Bicarbonate	73.		Magnesium Hardness CaCO3	32.	Al-Aluminum	<0.01
CO3 - Carbonate	0		Total Hardness CaCO3	60.	Mn-Manganese	<0.05
NO3 - Nitrate	<0.01		Total Dissolved Solids 180°C	84.	Fe-Iron	0.03
			Total Suspended Matter	<1.0		
TOTAL ME/L**					Phenol	
MAJOR CATIONS					Grease & Oil	<1.0
Ca - Calcium	11.					
Mg - Magnesium	7.8				Heavy Metals (As Group)	
			Turbidity (Turbidity Units)	0.40 FTU	ABS	
Na - Sodium	6.4				Hg-Mercury	2.2 ug/l
K - Potassium	<1.0		Hydrogen Ion Concentrate (pH)	7.8		
TOTAL ME/L**			Sp. Cond.-Micromhos 25°C	120		

* Milligrams Per Liter
** Milliequivalents Per Liter

Included in Standard Mineral Analysis

COMMENTS:

WORK AUTHORIZED Burmah Oil Corporation

SUPPLY OWNED BY

ANALYSIS NO. 875-4403

DATE COMPLETED 8-22-75

ANALYST J. Brunsden by S.E.D.

425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIF. 95403 TELEPHONE (707) 544-8807

LABORATORIES 425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIFORNIA 95403 TELEPHONE (707) 544-8807

BACTERIOLOGICAL EXAMINATION OF WATER

or Burmah Oil Corporation
1100 C Coddingtown Center
Santa Rosa, Calif. 95406

Date Reported August 26, 1975
Collected by

Analysis Number	Date Collected	Date Completed	Sample Source	Coliform MPN/100 ml	Safe	Unsafe
875-4586	8-20-75	8-24-75	Anderson Creek at Conf. with Putah Creek	≥2400		

BACTERIOLOGICAL SUMMARY

Scheduled System Samples, this report:
No. samples
No. samples with 3 or more + tubes
No. 10 ml. tubes No. + 10 ml tubes

Analyst J. Amundson by A.E.D.

BRELJE AND RACE

LABORATORIES 425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIFORNIA 95403 TELEPHONE (707) 544-8807

BACTERIOLOGICAL EXAMINATION OF WATER

For Burmah Oil Corporation
1100 C Coddingtown Center
Santa Rosa, Calif. 95406

Date Reported August 26, 1975
Collected by

Analysis Number	Date Collected	Date Completed	Sample Source	Coliform MPN/100 ml	Safe	Unsafe
875-4589	8-20-75	8-24-75	Gunning Creek Upstream Socrates Mine Road	240		

BACTERIOLOGICAL SUMMARY

Scheduled System Samples, this report:
No. samples
No. samples with 3 or more + tubes
No. 10 ml. tubes No. + 10 ml tubes

Analyst J. Amundson by G. E. D.

BRELJE AND RACE

LABORATORIES 425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIFORNIA 95403 TELEPHONE (707) 544-8807

BACTERIOLOGICAL EXAMINATION OF WATER

For Burmah Oil Corporation
1100 C Coddingtown Center
Santa Rosa, Calif. 95406

Date Reported August 26, 1975
Collected by

Analysis Number	Date Collected	Date Completed	Sample Source	Coliform MPN/100 ml	Safe	Unsafe
875-4588	8-20-75	8-24-75	Castle Rock Creek 500 ft. Upstream Anderson Creek	1100		

BACTERIOLOGICAL SUMMARY

Scheduled System Samples, this report:
No. samples
No. samples with 3 or more + tubes
No. 10 ml. tubes No. + 10 ml tubes

Analyst J Amundson by A.E.D.

BRELJE AND RACE

LABORATORIES 425 SOUTH E STREET P. O. BOX 1895 SANTA ROSA, CALIFORNIA 95403 TELEPHONE (707) 544-6807

BACTERIOLOGICAL EXAMINATION OF WATER

For Burmah Oil Corporation
1100 C Coddingtown Center
Santa Rosa, Calif. 95406

Date Reported August 26, 1975
Collected by

Analysis Number	Date Collected	Date Completed	Sample Source	Coliform MPN/100 ml	Safe	Unsafe
875-4587	8-20-75	8-24-75	Bear Canyon Creek 20 ft. upstream from Anderson Crk.	1100		

BACTERIOLOGICAL SUMMARY

Scheduled System Samples, this report:
No. samples
No. samples with 3 or more + tubes
No. 10 ml. tubes No. + 10 ml tubes

Analyst J Amundson by G.E.D.

APPENDIX J

WATER QUALITY AND AQUATIC BIOLOGY

Organisms Collected at Station 1

Ephemeroptera
- Ironodes nitidus
- Iron longimarus
- Ephemorella flavilinea
- Ephemorella cognata
- Ephemerella tibialis
- Baetis sp. 1
- Baetis sp. 2

Odonata
- Gomphus morrisoni
- Lanthus sp.
- Libellulidae sp.

Plecoptera
- Peltoperla
- Acroneuria californica
- Acroneuria pacifica
- Alloperla sp.

Magalopetera
- Dysmicohermes crepusculus

Hemiptera
- Gerris remigis

Trichoptera
- Glossosoma sp.
- Rhyacophila sp. 1
- Rhyacophila sp. 2
- Hydropsyche sp.
- Polycentropis sp.
- Wormaldia sp.
- Protoptila sp.

Coleoptera
- Hydroporus sp. (Dytiscidae)
- Deronectes sp. (Dytiscidae)
- unknown Elmidae

Diptera
- Bibiocephala sp. (Blephaceridae)
- Blepharicera osten-sackeni (Blephariceridae)
- Atherix sp. (Rhagionidae)
- Limnophila sp. (Tipulidae)
- Hexatoma sp. (Tipulidae)
- Dicronota sp. (Tipulidae)
- Simulium sp. (Simuliidae
- Dixa sp. (Dixidae)
- 3 Chironomidae sp.

Potamobiidae
- Potamobius sp.

Salmonidae
- Salmo gairdnari

Organisms Collected at Station 2

Collembola
- Isotomidae sp.

Ephemeroptera
- Ephemerella flavilinea
- Ephemerella cognata
- Baetis sp. 1
- Baetis sp. 2
- Paraleptophlebia sp.

Odonata
- Coenagrionidae naiad
- Gomphidae naiad

Plecoptera
- Peltoperla sp.
- Nemoura sp.
- Acroneuria californica
- Alloperla sp.

Megaloptera
- Neohermes californicus

Hemiptera
- Gerris remigis

Trichoptera
- Glossosoma sp.
- Rhyacophila sp. 1
- Rhyacophila sp. 2
- Polycentropis sp.

Coleoptera
- Acneus sp. (Psphenidae)
- Agabus sp. (Dytiscidae)
- Deronectes sp. (Dytiscidae)
- Hydroscapha sp. (Hydroscaphidae)
- Staphylinidae sp.
- Crenitis sp. (Hydrophilidae)
- Helocombus sp. (Hydrophilidae)

Diptera
- Limonia sp. (Tipulidae)
- Dicronota sp. (Tipulidae)
- Unidentified (Tipulidae)
- Chrysops sp. (Tabanidae)
- Simulium (Simuliidae)
- Dixa sp. (Dixidae)
- Palpomyia sp. (Geratopagonidae)
- 4 Chironomidae sp.
- 1 unidentifiable Diptera

Salmonidae
- Salmo gairdnari

Organisms Collected at Station 3

Ephemeroptera
- Iron sp.
- Baetis sp. 1
- Ephemerella flavilinea
- Ephemerella cognata
- Paraleptophlebia sp.
- Tricorythodes fallax

Odonata
- Erpetogomphus sp.
- Aeshna sp.

Plecoptera
- Nemoura sp.
- Allperla sp.
- Acroneuria californica

Hemiptera
- Gerris remigis

Trichoptera
- Glossosoma sp.
- Rhyacophila sp. 1
- Polycentropis sp.
- Hydropsyche sp.
- Hydroptilidae sp.

Coleoptera
- Eubrianax (Psphenidae)
- Deronectes sp. (Dytiscidae)
- Opitoservus sp. (Elmidae)
- Unidentified (Hydrophilidae)
- Gyrinus punctellus (Gyrinidae)

Diptera
- Dicronota sp. (Tipulidae)
- Limnophila sp. (Tipulidae)
- Limonia sp. (Tipulidae)
- Dixa sp. (Dixidae)
- Simulium sp. (Simuliidae)
- Palpomyia sp. (Ceratopogonidae)
- 3 Chironomidae sp.

Potamobiidae
- Potamobius sp.

Organisms Collected at Station 4

Ephemeroptera
- Ironodes nitidus
- Iron sp.
- Ephemerella flavilinea
- Ephemerella tibialis
- Ephemerella cognata
- Baetis sp. 1
- Paraleptophlebia sp.

Odonata
- Gomphus sp.
- Gomphidae sp.
- Coenagrionidae sp.
- Libellulidae sp.

Plecoptera
- Nemoura sp.
- Alloperla sp.
- Acroneuria californica
- Acroneuria pacifica
- Peltoperla sp.
- Pteronarcys sp.

Hemiptera
- Gerris remigis

Trichoptera
- Helicopsychidae sp.
- Glossosoma sp.
- Rhyacophila sp. 1
- Rhyacophila sp. 2
- Polycentropis sp.
- Hydropsyche sp.

Coleoptera
- Deronectes sp. (Dytiscidae)
- Hydroporus sp. (Dytiscidae)
- Hydrophilidae sp.
- Elmidae sp.

Diptera
- Blepharicera osten-sackeni (Blephariceridae)
- Dicronota sp. (Tipulidae)
- Limnophila sp. (Tipulidae)
- Hexatoma sp. (Tipulidae)
- Chrysops sp. (Tabanidae)
- Dixa sp. (Dixidae)
- Simulium sp. (Simuliidae)
- Palpomyia sp. (Ceratopogonidae)
- 5 Chironomidae sp.
- 3 unidentified Diptera

Salmonidae
- Salmo gairdnari

Organisms collected at
Station 5

Ephemeroptera
- Iron sp.
- Ironodes nitidus
- Paraleptophlebia
- Ephemerella flavilinea
- Ephemerella cognata
- Ephemerella tibialis
- Baetis sp.

Odonata
- Gomphidae sp.
- Coenagrionidae sp.

Plecoptera
- Nemoura sp.
- Alloperla sp.
- Acroneuria californica
- Acroneuria pacifica
- Pteronarcys sp.

Megaloptera
- Neohermes californica

Himiptera
- Gerris remigis

Trichoptera
- Rhyacophila sp. 1
- Glossosoma sp.
- Hydropsyche sp.
- Polycentropis

Coleoptera
- Deronectes sp. (Dytiscidae)
- Eubrianas sp. (Psphenidae)
- Hydrophilidae sp.
- Elmidae sp.

Diptera
- Simulium sp. (Simuliidae)
- Hexatoma sp. (Tipulidae)
- Dicronota sp. (Tipulidae)
- Blepharicera osten-sackeni (Blephariceridae)
- Deuterophlebia (shasta) (Deuteraphlebiidae)
- Palpomyia sp. (Ceratopogonidae)
- 4 sp. Chironomidae
- 2 unidentifiable Diptera

Cottidae
- Cottus gulosus

Salmonidae
- Salmo gairdnari

Organisms collected at
Station 6

Ephemeroptera
- Iron sp.
- Baetis sp. 1
- Ephemerella cognata
- Ephemerella flavilinea

Odonata
- Gomphidae sp.
- Coenagrionidae sp.
- Libellulidae sp.

Plecoptera
- Alloperla sp.
- Acroneuria californica
- Acroneuria pacifica

Hemiptera
- Gerris remigis

Trichoptera
- Glossosoma sp.
- Rhyacophila sp.
- Hydropysche sp.
- Polycentropis sp.

Coleoptera
- Gyrinus punctellus (Gyrinidae)
- Eubrianax sp. (Psphenidae)
- Deronectes sp. (Dytiscidae)
- Hydrophilidae sp.
- Elmidae sp.

Diptera
- Dicronota sp. (Tipulidae)
- Hexatoma sp. (Tipulidae)
- Atherix sp. (Rhagionidae)
- Palpomyia sp. (Ceratopogonidae)
- 3 or 4 Chironomidae sp.
- 1 unidentifiable diptera

Salmonidae
- Salmo gairdnari