MASTER
Occidental Geothermal, Inc.
OXY GEOTHERMAL
PLANT NO. 1

Draft Environmental
Impact Report

AUGUST 1981

CALIFORNIA
ENERGY
COMMISSION

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Occidental Geothermal, Inc.
Oxy Geothermal Power Plant No. 1

DRAFT
ENVIRONMENTAL IMPACT REPORT

Prepared by
California Energy Commission
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SUMMARY

PROJECT

POWER PLANT

On January 29, 1981, Occidental Geothermal, Inc., (Oxy) filed an Application for Certification (AFC) with the California Energy Commission (CEC). The Oxy AFC contains a proposal to construct an 80 megawatt (MW) geothermal power plant at The Geysers-Calistoga Known Geothermal Resource Area (KGRA). The power plant, Oxy Geothermal Plant No. 1, would be located in Lake County near the Sonoma County line. Its appearance and operation will be basically the same as other geothermal units in operation or under construction in the KGRA. Steam to run the power plant will come entirely from within the Oxy leasehold.

STEAM FIELD

Unlike most geothermal developments in the KGRA, Oxy will be both the steam supplier and the steam user (i.e., they will develop the steam field and run the power plant). Thus, Oxy has a great potential for coordinating steam field and power plant development to reflect environmental sensitivity. Development of the well field precedes the construction of the power plant. Permit authority and jurisdiction over Oxy's well field development lies with the United States Geological Survey (USGS), whereas CEC has the authority to certify construction of the power plant.

For environmental documentation on the development of the Oxy steam field, the reader may wish to consult the following documents, all of which are available either through the Ukiah District Bureau of Land Management Office or at the USGS office in Menlo Park. Address any requests for USGS material to USGS, Conservation Division, Deputy Conservation Manager for Geothermal, 345 Middlefield Road, M.S. 92, Menlo Park, CA 94025, (415) 323-8111 ext. 2841. Address requests for The Geysers Mineral Reserve Lands (Five Tracts) E.A.R. to the Bureau of Land Management, 555 Leslie Street, Ukiah, CA 95482, (707) 462-3873.

1. ENVIRONMENTAL ASSESSMENT 174-81--U.S. Department of the Interior, Geological Survey, Deputy Conservation Manager for Geothermal, Menlo Park, California--July 14, 1981.
2. THE GEYSERS MINERAL RESERVE LANDS (Five Tracts)--Proposed Geothermal Environmental Assessment Record (draft). U.S. Department of the Interior, Bureau of Land Management, Ukiah District, California--September 1978.
3. ENVIRONMENTAL ASSESSMENT 121-9 (Checklist Analysis)--U.S. Department of the Interior, Geological Survey Area, Geothermal Supervisors Office, Conservation Division, Menlo Park, California--July 1979.
4. ENVIRONMENTAL ASSESSMENT 131-81--U.S. Department of the Interior, Geological Survey, Area Geothermal Supervisors Office, Menlo Park, California--December 1980.

5. FINAL ENVIRONMENTAL ASSESSMENT 149-80---U.S. Department of the Interior, Geological Survey, Conservation Division, Menlo Park, California--August 1980.

Basically all of the environmental documentation indicates the sensitivity of placing a geothermal development at the top of a relatively fragile watershed, which provides both potable and recreational waters for the people in the town below. CEC staff shares this concern as discussed in the Hydrology/Water Quality section of the EIR.

PROJECT FEATURES

Air Emissions Abatement Systems

Historically public concerns focus on the air pollution and odor caused by geothermal developments. The incoming geothermal steam supply contains a number of potentially toxic substances. Of these, hydrogen sulfide (H_2S) presents the greatest potential for adverse impacts from spent steam emissions. Unabated emissions of H_2S may produce an increasing number of localized complaints about odor and the potential for disagreeable physical reactions in sensitive public populations. Because of the current level of geothermal development at The Geysers, the cumulative effects of H_2S emissions have resulted in violations of the state standard for ambient H_2S at the populated areas nearest the proposed Oxy power plant, although H_2S violations have decreased in recent years.

Oxy proposes the Stretford chemical "scrubbing" process in combination with surface condensers as the primary air emissions abatement systems. Additionally, Oxy will use a Hydrogen Peroxide (H_2O_2) secondary abatement system to further reduce emission of air pollutants.

To reduce "stacking" impacts Oxy will employ turbine bypass devices on each of the generating units. Such design features allow the steam to bypass either or both turbines and enter the surface condenser directly, after which the Stretford and condensate abatement systems treat the steam before it enters the atmosphere. If only one turbine is out of operation, the excess steam will go to the operating turbine to generate power.

Site Preparation

Preparation of a level site for the power plant and related facilities (including access road to the power plant) will require alteration of approximately 16.7 acres. Oxy intends to balance the cut and fill and will use any excess material either on the power plant site itself or on roads and well pads within the 550 acre leasehold. Construction of the proposed power plant will not result in disposal problems for excess earth. Oxy intends to complete construction and begin operation by May 1984.

Power Plant Design

Key elements which affect the environment are identified below.

Steam Supply

The Oxy power plant will require approximately 1,500,000 pounds per hour of steam; it will require 7 to 12 wells to furnish this supply. Over the 30-year lifetime of the power plant, Oxy may require as many as 30 wells, depending on the flow rate and duration of each supply well. Steel pipelines will convey the steam to the power plant, where the steam flow will drive turbines, which in turn rotate the generator and produce electricity.

Twin Units

Oxy will employ twin turbines and generators, each of which could independently produce nearly 70 MW of net electrical output in case one unit fails. However, their system design includes governors on the generators which will limit the total combined electrical output to 80 MW.

Condensers

In order to increase the efficiency of the power plant, the design must condense the spent steam from the turbines. Heat is extracted from the spent steam in the unit condensers causing the steam to transform to the liquid state. The condensed spent steam provides the source of makeup water to replace water which is lost during the operation of the cooling system. The proposed power plant will use surface condensers, which capture a greater portion of the environmentally undesirable hydrogen sulfide with the noncondensable gases than the direct contact condensers used in the older units at The Geysers. The design can more easily treat hydrogen sulfide contained in the noncondensable gas stream than the hydrogen sulfide contained in the liquid condensate stream.

Cooling Towers

The heated circulating cooling water goes to the cooling towers where the heat is transferred to the air by contact with the air and evaporation. The proposed power plant will use two 5 cell cooling towers. The condensed spent steam also goes to the cooling tower to replace water lost during the cooling cycle. The cooling tower basins collect the condensate and the cooled circulating cooling water. The cooled waters are then pumped back to the unit condensers for additional condensation of spent steam.

The condensed steam exceeds the amount of water lost through evaporation during the cooling process. Therefore, no extra source of replacement water is required. The excess water which remains after cooling is piped back into the ground in a nonproductive well. Although no outside source of water is required to replenish the cooling water lost from evaporation, an initial supply has to be furnished from independent sources in order to start operating the power plant. This initial supply is approximately 1,000,000 gallons (3 acre-feet). Oxy will place it in the collecting basin at the bottom of the cooling tower. Oxy intends to furnish the initial start-up water from sources outside the leasehold.

TRANSMISSION LINES

Oxy plans to construct a transmission tapline from the power plant to an existing 230 kV transmission line in The Geysers. They identified two possible routes for the tapline, but the preferred one would go west over the ridge top and join the SMUDGE #1 tapline. This route would be 4,700 feet long and would require 3 transmission towers.

PROJECT-SPECIFIC AND CUMULATIVE ENVIRONMENTAL ANALYSES

This text summarizes both project-specific impacts and cumulative environmental impacts which will result from Oxy's proposal. The project-specific analysis deals only with impacts resulting from the power plant itself, access roads, and transmission lines, whereas the cumulative environmental analysis discusses impacts from activities which occur beyond the power plant site and outside the transmission line right-of-way. The discussion of cumulative impacts includes the results of full leasehold development and places the Oxy development in perspective with geothermal activities in the rest of the KGRA. Both the project-specific and cumulative impacts of the Oxy proposal are summarized below.

GEOLOGY

CEC staff believes that the power plant will be designed to withstand a reasonably predictable level of earthquake activity and that neither landsliding nor fault-rupture will endanger the power plant or appurtenant facilities.

Oxy's development, as a part of geothermal development of the entire KGRA, will add to the overall depletion of the steam reservoir. The rate of reservoir depletion, however, is uncertain.

SOILS

Project-specific erosion may occur during construction of the power plant facilities and for about three years afterwards near culverts, cuts, and fills until revegetation and stabilization occurs. Oxy will implement a series of mitigation measures to reduce the potential for erosion. CEC staff believes that these mitigation measures will be adequate to reduce erosion to a more acceptable level.

Total project development (including the steamfield) will disturb approximately 51 acres or 9 percent of the 550 acre leasehold. This amount of disturbance is not unusual in itself; however, the Oxy leasehold is located on highly erodible soils at the very top of a watershed, which supplies both recreational and domestic water for approximately 200 permanent and an additional 500 seasonal residents downstream of the Oxy leasehold. The potential for degrading the local people's source of water is therefore a sensitive matter. With respect to the entire KGRA, Oxy's project will add incrementally to overall soil losses in the Geysers area, and if mitigation measures are unsuccessful, soils from the leasehold could enter the larger Putah Creek drainage system and finally deposit in Lake Berryessa.

Oxy will mitigate erosion and degradation of local streams through the following methods:

- o Revegetate denuded slopes and fill surfaces,
- o Pave the internal access road from drill site C to B prior to construction of the well pads,
- o Incorporate sound engineering practices such as water bars, drains, culverts, berms to control the flow of waters from their leasehold into local creeks, and
- o Oxy will implement a water quality monitoring program which will identify whether further mitigation measures are necessary.

HYDROLOGY/WATER QUALITY

Clearing vegetation from the 16.7 acre plant site and surrounding area will temporarily increase the potential for erosion and sediment deposition into an intermittent tributary to Anderson Creek; however, revegetation efforts should restabilize the soil within about three years.

Oxy will install a sediment pond and system of ditches and drains to prevent heavy loads of sediment from the plant site from entering Anderson Creek.

The Oxy leasehold is located at the top of a watershed which supplies agricultural, recreational and domestic water to downstream residents. The total development of this project (power plant, access roads, and steamfield) could place a high sediment load in these waters and thereby alter the water quality. Such degradation to local creeks could impact recreational and domestic use as well as alter the aquatic ecosystems which affect fish and other aquatic organisms.

Existing geothermal developments in the area have already impacted Anderson Creek, which is the primary source of recreational water for local residents. However, Gunning Creek, the main source of domestic water, has been relatively untouched by geothermal development. Oxy's well pad B may impact Gunning Creek, which is the last pristine creek in the watershed and supplies domestic water to 200 permanent and an additional 500 seasonal downstream residents.

Transport of potentially toxic or harmful substances related to the H₂S abatement system(s) creates the possibility that these materials could be spilled and enter surface waters. The probability of major accidental spills during transport is relatively low and can be mitigated by improved safety precautions and training.

Based on historical data, condensate spills and drilling waste could also damage the waters. To prevent adverse impact to water quality, Oxy will implement appropriate mitigation measures listed under Soils. They will also develop a contingency plan to promptly supply downstream users with domestic water in case toxic chemicals from the Oxy leasehold enter the potable water source.

Various regulatory agencies (Lake County, California Energy Commission, Central Valley Regional Water Quality Control Board, the United States Geological Survey, and Bureau of Land Management) have expressed concern over the potential degradation of this watershed due to geothermal development. In addition to Oxy's mitigation measures, these agencies will help Occidental and other developers who affect this watershed implement a monitoring program which will identify whether additional mitigation measures will be required.

BIOLOGY

Vegetation

Construction of the power plant site access road and transmission line will remove approximately 21 acres of vegetation. Disturbance of approximately 59 acres of total land within the Oxy leasehold will reduce various vegetation types. None of these losses are expected to directly impact legally protected species, species of special concern, or species of commercial importance; however, Oxy has not yet completed adequate studies on the occurrence of rare species.

Wildlife

As explained under Soils and Hydrology/Water Quality, sediment entering local streams could result in serious impacts to aquatic biota, which include (among others) the recreational species, rainbow trout. Should a toxic spill occur and enter the creeks, it could kill fish and other forms of aquatic life.

The loss of vegetation due to Oxy's full project will reduce habitat for a number of wildlife species; however, if mitigated, these impacts should not be significant. The one fully protected species which Oxy's development may affect is the ringtail. This small raccoon-like creature frequents riparian zones. Although CEC staff considers the Oxy leasehold likely to contain ringtail, the impacts to this fully protected species cannot be assessed due to lack of data concerning their existence on the leasehold.

Oxy's well pad B and access road between pads B and C infringe upon the riparian protection zone recommended in 1978 by the U.S. Bureau of Land Management to preserve wildlife habitat along creeks in the leasehold.

AIR QUALITY

The Oxy project will contribute incrementally to an existing air quality problem caused by geothermal development in the KGRA. The Lake County Air Pollution Control Officer (LCAPCO) has the responsibility to determine whether the project will comply with applicable rules and standards. CEC staff anticipates that the LCAPCO will issue a Determination of Compliance which indicates that Oxy will use best available control technology (BACT) to limit H₂S emissions to 7.5 pounds per hour. Compared to existing geothermal plants in the KGRA, the Oxy plant will be relatively clean in terms of H₂S emissions.

The Oxy #1 H₂S emissions will not cause ambient air quality violations in the KGRA. Regardless of Oxy's use of BACT, CEC staff does not expect a reduced number of violations, since existing unabated plant emissions are the major contributors to the violations and since the existing plants will not significantly reduce their emission by the time the Oxy plant begins operation in 1984.

Emissions of potentially deleterious substances which are present in geothermal steam and/or the cooling tower plume may be carried in the air and deposited on soils, vegetation, wildlife, and populated areas. The effect of small concentrations and cumulative deposition of substances such as mercury, arsenic, boron, and radon-222 daughters are not sufficiently understood, and the significance of the impacts is unknown. Oxy will reduce rates and amounts of emissions by appropriate design of the cooling towers and other facilities.

NOISE

If Oxy implements all proposed mitigation measures, operation of the power plant will not result in significant noise impact.

Sensitive receptors near the steamfield may hear such activities as production testing, unmuffled well venting, and wellhead master valve changes. These activities occur infrequently and can be restricted to daylight hours. Construction traffic along access routes to the leasehold may subject people along the route to intermittent noise levels which exceed the nighttime standard of the Lake County draft noise ordinance; such traffic should be limited to daylight hours.

WASTE MANAGEMENT

Hazardous substances stored at the power plant will be contained in appropriate vessels to ensure against accidental spills, but as a further precaution, Oxy will place curbs which are large enough to contain any spilled material around the entire plant site and individual H₂S abatement and chemical handling areas.

Oxy #1's Stretford system will produce approximately 676 cubic yards of sulfur and sludge per year, and the H₂O₂ secondary abatement system may produce about 3.5 cubic yards of sludge per year. Oxy will dispose of wastes at approved disposal sites in Martinez, Middletown, and Kelseyville.

Impermeable sumps will contain drilling muds and liquids during the lifetime of the well. When a well is abandoned, Oxy will test these muds and either remove them to appropriate disposal sites if they contain any toxic/hazardous substances, or bury them in the sump if there are no harmful substances. Geothermal drilling muds in The Geysers KGRA historically consist of natural soils and bentonite clays, neither of which is considered harmful to the environment.

Although the potential exists for a sump to fail and spill drilling muds into Anderson Creek which receives high recreational use, Oxy will mitigate this

potential impact through proper construction and routine observation of sump levels and condition. CEC staff anticipates no adverse impact from hazardous wastes, provided Oxy stores and disposes of wastes according to regulation.

HEALTH

The project will contribute, albeit in relatively small amount, to existing violations of the California Ambient Air Quality Standard for H_2S . Although experts do not know at this time if adverse health effects result from exposure to low levels of H_2S , the inference is that increasing H_2S concentrations will increase the possibility of public odor complaints as well as the possibility for adverse health impacts in The Geysers area. In addition, the project's emissions of nonregulated pollutants, combined with other power plant emissions, increase the possibility of adverse health impacts from these pollutants.

There is a possibility that the construction and operation of the Oxy facility may degrade local recreation and drinking water supplies. Oxy has agreed to periodically monitor water quality in Anderson and Gunning creeks to detect any chronic degradation so that appropriate corrective actions may be taken.

TRANSPORTATION

CEC staff does not expect the small increase in light weight (auto/ truck) traffic due to Oxy's construction to significantly impact the local transportation network. Oxy's increase in heavy truck traffic, however, will worsen existing problems on Socrates Mine Road. If Oxy disposes of wastes in Middletown, their disposal trucks will add to an existing deterioration problem on Butts Canyon Road.

Oxy and other geothermal developers will share the costs of improving Socrates Mine Road. CEC staff views the maintenance of Butts Canyon Road as a problem which the county can remedy.

ENERGY AND MATERIAL RESOURCES

The Oxy #1 plan would consume approximately 1,500,000 lbs/hr of geothermal steam. To prevent steam from venting unabated into the air during occasional shut-downs, Oxy will employ independent dual turbines so that one unit could run while the other shuts down. The design includes turbine bypass devices so that during a shut-down, steam would bypass the turbine and enter the air abatement system. Additionally, Oxy will use a governor to throttle back unwanted steam. Oxy could maximize the use of geothermal steam by incorporating a more efficient turbine design.

On a cumulative level, Oxy #1's use of energy and material resources is about on a par with other geothermal developments in the KGRA, although recent design technology indicates that Oxy could increase their turbine efficiency.

CEC staff estimates that by 1986 a total of 24 geothermal power plants may operate in the KGRA, and will consume an estimated 28,305,000 lbs/hr of geothermal steam.

CULTURAL RESOURCES

The Oxy development area contains one significant prehistoric hunting camp site, which is listed on the National Register of Historic Places. Oxy will establish a buffer zone to protect this site, although no construction activities are planned for the area. If Oxy implements all mitigation measures, no adverse impact to cultural resources should occur.

SOCIOECONOMICS AND PUBLIC SERVICES

CEC Staff anticipates significant socioeconomic impacts due to Oxy and other geothermal developments. These will occur primarily in Lake and Sonoma, and to a much lesser extent in Napa and Mendocino Counties. Specifically, there will be an increased demand for housing on an already impacted housing market and an increased burden on public schools, especially within Lake County. Staff recognizes the potential for the Oxy development to cause a significant public service impact on the water system for Anderson Springs. Cautious engineering and adequate mitigation measures may dispell this concern.

LAND USE

The Oxy proposal is consistent with both Lake and Sonoma County General Plans. The project will add further geothermal development to the KGRA.

AESTHETICS

The Oxy project will be visible from portions of the Colloyami and Longs Valleys to the east, and from part of Highways 29 and 175. It will be partially visible from the vicinity of Anderson Springs, Middletown and Whispering Pines, although geothermal development is common in the KGRA.

Oxy's preferred transmission corridor (westward over the ridge to SMUDGE #1) will be visible from the valleys to the east. However, the preferred route would be less visible than the alternate route which would traverse the ridge to the south-south-west.

Cumulative geothermal development (Oxy #1 and others) in this watershed will degrade the water quality of Anderson Creek. Anderson Creek mainly provides recreational waters for local residents, so the visual impact of increased sediment and pollution may lessen the creek's recreational appeal.

INTRODUCTION

THE PROPOSED PROJECT

Occidental Geothermal, Inc., (Oxy) filed an Application for Certification with the California Energy Commission on January 29, 1981, to construct and operate Oxy #1 geothermal power plant. Oxy's proposed power plant will have a net normal operating capacity of approximately 80 MW. It is scheduled for operation in 1984, provided that construction begins in spring 1982. Oxy indicates that the power plant would be operational for about 30 years (81-AFC-1).

Oxy #1 would be located on private land in western Lake County. A small portion of the leasehold extends into Sonoma County. The federal government holds subsurface mineral rights on the property, and Oxy has a 40-year lease from the U.S. Bureau of Land Management to develop the subsurface geothermal resource. Development of the steam field is administered by the BLM and USGS. The California Energy Commission has authority to review and approve construction and operation of the power plant, access road, and transmission lines. If the overall proposal is found to be suitable, the Energy Commission has the authority under state law to certify the power plant for operation.

THE FUNCTION OF THIS DOCUMENT

This Draft Environmental Impact Report (DEIR) addresses environmental concerns according to the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA). The purpose of this study is to discuss and to allow the public an opportunity to comment on the environmental impacts which would be caused by the proposed 80 MW geothermal power plant.

This environmental impact report identifies the significant effects of the project on the environment; it identifies alternatives to the project and indicates the manner in which environmental effects can be mitigated or avoided. A significant effect on the environment is a substantial or potentially substantial change in the environment.

The DEIR is not meant to present a conclusion regarding the overall acceptability of the project. The Energy Commission will use this report, in combination with other materials, to determine whether, and under what conditions, the project should be approved.

The staff of the Energy Commission, hereafter referred to as "staff," prepared this DEIR in accordance with the NEPA, CEQA, the State EIR Guidelines, and the Energy Commission's regulations to implement CEQA. Staff used information from both published and unpublished sources. The primary document the staff used was Oxy's AFC. The staff collected other information from the AFC proceedings (81-AFC-1), from federal, state, and local agencies, and from private groups or individuals. The reader may note minor discrepancies in the acreage figures presented in the Biology and Water Quality/Hydrology/Soils sections. This is due to discrepancies in the information which Oxy submitted; however, staff considers this level of detail unimportant in determining the significance of impacts. Although much of the information

presented in this environmental document was originally provided by Oxy, the staff examined it for its reasonableness and technical accuracy and conducted its own independent verification. The analysis of the environmental impacts and the determination of their significance were conducted by and are the responsibility of the staff.

The sections that follow discuss (1) the project as proposed by Oxy (Project Description); (2) the environment in the vicinity of the project as exists before the commencement of the project, from both a local and regional perspective (Environmental Setting); (3) the adverse consequences of the project, any significant environmental effects which cannot be avoided, and any mitigation measures to minimize significant effects (Impacts and Mitigations); (4) the potential feasible alternatives to the proposed project (Alternatives); (5) the significant unavoidable, irreversible, and long-term environmental impacts (Unavoidable Adverse Impacts); and (6) the Growth Inducing Impacts.

Where needed, the text includes graphic charts, tables, and figures to clarify the text. All references to graphics within the text refer specifically to graphics contained within that particular section of the EIR. For example, mention of Table 3 in the text on Noise refers to Noise Table 3.

An interdisciplinary team of environmental analysts from the Engineering and Environmental Division of the Energy Commission prepared this document. Specific staff are recognized under "Authors."

The depth of analysis of environmental effects is "in proportion to the severity and probability of occurrence" (Section 15140(e), State EIR Guidelines). Effects the staff considered insignificant are discussed in Appendix A, entitled Initial Environmental Impact Evaluation. Appendix A focuses on potentially significant impacts and documents why insignificant impacts were identified as such. Effects that staff classified as "unresolved" or "potentially significant" in the Initial Environmental Impact Evaluation are addressed in Chapters II and III, Project-Specific and Cumulative Environmental Analyses.

REVIEW PROCESS

A 45-day public review will follow the release of the Draft EIR. Staff encourages comments on this document, both with regard to substance of its content and to the clarity of its discussion. There are two ways in which to comment on the DEIR: (1) write to the Energy Commission at the address listed below and (2) attend a public workshop for the purpose of discussing this document. This workshop has been tentatively scheduled for September 16, 1981, 7:00 pm., Multi-Purpose Room, Middletown Unified School, Calistoga Avenue, Middletown, California. Another workshop may be scheduled, depending on public interest. If so, it will be publicly noticed.

The Final EIR will reflect comments made at the workshop(s) and in writing during the review period.

Written comments should be submitted to:

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I. PROJECT DESCRIPTION OBJECTIVES

Occidental Geothermal, Inc., proposes to construct and operate the Oxy Geothermal Plant No. 1 to provide an economic and nonfossil fuel source of 80 MW net electrical generation.

NEED

The California Energy Commission's Geothermal Policy Report, dated March 22, 1978, recognizes geothermal energy as a preferred technology for meeting electric power needs because (1) the geothermal resource is indigenous to California; (2) its development offers a stimulus to the state's economy; (3) the environmental impacts and power plant technology for dry steam resources are well understood; (4) geothermal power plants are relatively small (50 - 110 MW) and thus enable greater system reliability and flexibility; and (5) geothermal power plants may be planned and constructed in a shorter time frame than power plants using fossil or nuclear fuel.

In its 1979 Biennial Report, the California Energy Commission indicated that generation alternatives such as geothermal should be expanded because of their reliability and more stable costs. In the 1979 Biennial Report, the California Energy Commission declared: "We will continue to certify the maximum number of geothermal sites and facilities that demonstrate reasonably mitigable environmental impacts and that meet existing air and water quality standards. Any facility that meets these criteria will be deemed needed." (CEC, 1979) According to the AFC, the Oxy Geo #1 project would meet these criteria.

OVERVIEW

In The Geysers KGRA a typical geothermal development area contains steam wells, well pads, access roads, steam supply pipelines, a power plant, transmission lines connecting the power plant with the intended electricity service area. In most cases, the land or leasehold where the steam wells and power plant are located is owned by private individuals or the federal government. The land is then leased to a steam developer who supplies the steam to an electrical utility company. The steam supplier is also responsible for disposing of or reinjecting any steam condensate generated by the power plant.

Oxy is both the steam supplier and the steam user for the Oxy #1 project. Both the power plant site and geothermal steam field are located entirely on private land, under which Oxy holds the federal subsurface mineral lease. The federal government is primarily responsible for environmental documentation of well field development, and permitting authority for activities within the well field rests with the federal government (USGS) and with Lake County. For further information regarding activities on the leasehold, refer to the documents in the summary under Steam Field. Pacific Gas and Electric (PGandE) currently operates 15 geothermal power plants in The Geysers KGRA equalling a total installed electrical capacity of 908 MW. PGandE units 17 and 18 are under construction and are scheduled for operation in 1982. These PGandE plants will each have 110 MW of installed capacity. Also, DWR has a 55 MW power plant approved, the Northern California Power Agency (NCPA) has a 110 MW

plant currently under construction, and SMUD is building a 72 MW plant, all of which should be in operation by 1984. Completion of the currently certified power plants will bring the total installed electric capacity of the KGRA to 1,365 MW by 1984.

Power plants which are proposed but not yet certified by CEC are PGandE Unit 16 (110 MW), DWR South Geysers (55 MW), and Oxy Geo #1. If these plants are all certified and constructed on schedule, they will bring the total installed capacity at the KGRA to 1,610 MW by 1984. Projections for maximum development of the KGRA* indicate a maximum installation of 2,700 MW of dry steam production by 1992, and an additional 550 MW of hot water production by the year 2000.

HISTORY

On January 29, 1981, Oxy filed an Application for Certification (AFC) with the Energy Commission to construct and operate the Oxy #1 power plant. They have also filed appropriate applications with USGS and BLM to develop the well field. Previously, a lease was issued to Oxy by BLM to develop the subsurface geothermal resources. Subsequent involvement by BLM in lease activities is through the procedures and under the direction of USGS. The surface land itself is privately owned and has been homesteaded for stockgrazing purposes. The surface owner has not yet granted Occidental permission to build a power plant on the land, although well field development is under way.

Currently only 2 of the anticipated 7 to 12 steam supply wells have been drilled.

A Steam Resource Hearing was held by the CEC on March 2, 1981, to determine the adequacy and availability of steam to run the proposed geothermal power plant. As a result of this hearing, the steam field was deemed adequate.

LOCATION

The Geysers KGRA is a mountainous, rugged, and sparsely populated area located in the northern central portion of the Coastal Ranges (Description Figure 1). The proposed Oxy Geothermal #1 project and steam field are located approximately 66 miles north of San Francisco and 61 miles northwest of Sacramento. The site is located in western Lake County at an approximate elevation of 3,600 feet. The nearest communities are the unincorporated towns of Anderson Springs and Middletown, located in Lake County approximately 2-1/4 miles east southeast and 9 miles southeast of the site, respectively. The nearest major cities are Santa Rosa, located in Sonoma County, approximately 24 miles south of the site, and Lakeport, 22 miles north in Lake County.

The Oxy leasehold contains two federal subsurface leases, CA 5636, and CA 5637, which encompass approximately 550 acres, located in Township 11 North, Range 8 West, Mount Diablo Base Meridian Section 21: lots 5, 6, 11, 12, NE 1/4 Section 22: NE 1/4 NW 1/4, NE 1/4 SW 1/4, W 1/2 W 1/2.

*CEC, Renewable and Alternative Technologies Synopsis, Staff Draft, CEC-9/1980, Pub. #500-80-012.

OXY GEOTHERMAL #1

FIGURE 1: DESCRIPTION-The Geysers-Calistoga KGRA

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 2: DESCRIPTION—Leasehold Development Plan

Access to the site from the nearby community of Middletown in Lake County is via Highway 175 and Socrates Mine Road. Access from the west is via the Healdsburg-Geysers road from Jintown to The Geysers Resort and then past PGandE Geysers 14 to Socrates Mine Road.

Oxy plans to construct the preferred transmission line from the plant site 4,700 feet west over the ridge, to join PGandE's existing 230 Kv line which leads out of Units 9 and 10 to Castle Rock Junction. In order to reach the PGandE tapline, Oxy will share two transmission towers with SMUDGE #1, but Oxy would construct three new towers in order to reach the SMUDGE towers. Each new tower will be located on an existing access road.

FEATURES

The proposed power plant will have the following main features:

- o Two single cylinder, two-flow, nonextraction condensing, 3,600 rpm turbines operating independently.
- o Two generators, each a 3,600 rpm hydrogen cooled, three phase, synchronous unit directly coupled to each main turbine shaft.
- o Stainless steel surface condensers will condense spent steam exhausted from the turbines and will effect an increase in partitioning H_2S and other noncondensibles from previously used direct contact type condensers which mix the cooling water with the spent steam.
- o Two five-cell wet (evaporative) crossflow cooling towers will be used to dissipate the heat gained by the circulating cool water during its passage through each surface condenser.
- o A 3,000 foot injection pipeline running from the cooling tower to an injection well at nearby well pad C will dispose of excess condensate in compliance with Waste Discharge Requirements adopted by the Central Valley Region Water Quality Control Board.
- o A sedimentation basin.
- o A Stretford hydrogen sulfide abatement system in which hydrogen sulfide is scrubbed from the vent gas steam and catalytically oxidized to elemental sulfur. Oxy will use a secondary abatement system in the event that the Stretford system does not adequately abate emissions to an acceptable level. The secondary abatement system will employ hydrogen peroxide with catalyst.
- o Abatement system chemical storage tanks (H_2 and CO_2).
- o A shop, warehouse, and administration office building.
- o An electrical switchyard.
- o Sewage treatment plant.

- o Three new transmission towers located between the Oxy site and the SMUDGE #1 site.
- o A 4,700 foot long transmission tapline connecting to an existing 230 kV transmission line to the west of the site.
- o A 7,200 foot paved access road (internal to the leasehold).
- o Approximately 2,600 feet of additional unpaved access road, within the leasehold.

STEAM SUPPLY WELLS

Oxy itself will supply the steam necessary to run the proposed geothermal power plant. CEC staff anticipates that up to 30 wells may be needed over the lifetime of the power plant. Oxy anticipates that the plant will require 7 to 12 wells to generate power initially.

Although the Steam Resource Hearing, held March 2, 1981, determined that there is adequate steam available to run the Oxy #1 project, the steam production of a well typically declines over a period of time as the reservoir it draws from is depleted. Thus, as steam production wanes, additional wells will be drilled. In addition, one or two reinjection wells are required to dispose of excess steam condensates and cooling tower blowdown.

To date, only two wells have been drilled on the site, although drilling operations for more are planned. The permitting authority for wells rests with the USGS.

STEAM PIPELINES

Steam will be transported from the wells to the power plant in insulated steel pipelines supported above ground. Steam transmission lines are generally selected for the shortest distance to the generating unit, but the actual layout of the pipeline is largely dictated by the rugged terrain in The Geysers area. Where possible, pipelines will follow road alignments and will avoid unstable slopes.

WATER SUPPLY

Initial start-up water for the cooling tower will be supplied by Oxy using purchased water from outside the leasehold. Once the power plant is in operation, make-up water for the cooling towers will come from excess condensate. Oxy will inject additional excess condensate into a well at Pad C.

II. PROJECT-SPECIFIC ENVIRONMENTAL ANALYSIS

GEOLOGY

SETTING

REGIONAL GEOLOGY

The proposed project and the entire Geysers KGRA lie in the Central Mayacmas Mountains of the northern coast ranges. Works by McLaughlin (1977, 1978) and McLaughlin and Stanley (1976) describe the regional geology of the KGRA. Recent mapping of the area by the U.S. Geological Survey indicates that the Central Mayacmas Mountains represent a structurally complex mass of rock which was uplifted by folding and faulting (Geology Figure 1).

The Geysers region experienced a series of folding, faulting, and volcanic events over the last several tens of millions of years. The present range was produced by accelerated folding and faulting which occurred during the last three to six million years. The Collayomi and Maacama faults form the northeast and southwest boundaries, respectively, of the Mayacmas uplift. Volcanism occurred in the area during the last five million years and formed Cobb Mountain and other volcanic features in the Clear Lake region within the last two million years. Presently a large body of at least partially molten magma exists at a depth of about 6 miles (10 kilometers) below the Clear Lake area (Donnelly et al., 1977) (Geology Figure 2).

The principal faults within The Geysers region are associated with the complex horst* which forms the Mayacmas Mountains. The fumarole activity along Big Sulphur Creek at The Geysers is a surface phenomenon often associated with faulting in an area characterized by recent volcanism (Hamilton and Muffler, 1972).

REGIONAL SEISMICITY

Moderate seismic activity occurs in the KGRA region where the potential seismicity of the San Andreas, Maacama, and Rodgers Creek faults overshadow that of other possible sources (Geology Figure 3 and Geology Table 1). Few earthquakes of magnitude 5.5 or greater have occurred in The Geysers region. The largest historical earthquakes of importance for The Geysers area are the 1969 Santa Rosa earthquake (M 5.6 and 5.7) on the Rodgers Creek Fault and the 1906 San Francisco earthquake (M 8.25) on the San Andreas Fault.

Geologic and seismic evidence indicates that both the San Andreas and Rodgers Creek Faults have a significant potential for producing strong earthquakes. Although few strong seismic events can be confidently associated with the Maacama Fault, recent tectonic interpretations (Herd, 1978; Dott, 1979) and geologic evidence indicate that this fault has a significant potential for generating strong earthquakes.

*A portion of the earth's crust which has been elevated and separated from the surrounding land by faults.

OXY GEOTHERMAL #1

Source: McLaughlin and Stanley, 1975 AMENDED BY PG&E, OCTOBER 1977

Source: Geysers 18 Final EIR

FIGURE 1: GEOLOGY- Geologic Map of Geysers

Source; Geysers 18 Final EIR

FIGURE 2: GEOLOGY—Cross Section Through the Geysers—Clear Lake Region

Structural model for the Geysers geothermal system. Cross-section through The Geysers-Clear Lake region, from the Maacama fault zone on the southwest, to Mount Konocti on the northeast, depicting structural elements of The Geysers-Clear Lake geothermal system.

Source: "Field-trip Guidebook Castle Steam Field, Great Valley Sequence," April 29, 1978, 53rd Annual Meeting, Pacific Sections AAPG, SEPM, SEG. Modified by the California Energy Commission, February, 1979.

OXY GEOTHERMAL # 1

REF: Modified after Jennings, C.W., 1975, Fault Map of California, Calif. Div. of Mines & Geol., Calif. Geologic Data Map Series, Map No. 1.

FIGURE 3: GEOLOGY-Regional Quaternary Faults

GEOLOGY TABLE I

CHARACTERISTICS OF SELECTED QUATERNARY FAULTS IN THE GEYSERS REGION

<u>CHARACTERISTICS</u>	<u>SAN ANDREAS</u>	<u>HEALDSBURG/ RODGERS CREEK</u>	<u>MAACAMA AND ASSOCIATED FAULTS</u>
DISTANCE FROM SITE (km)	53	32	13
MAPPED LENGTH (km)	1,200	42	16.5
TYPE OF FAULT	Right-lateral Strike-slip	Right-lateral Strike-slip probably some small vertical component	Right-lateral Strike-slip
ACTIVITY STATUS			
1) Historic activity	Yes	Yes	Yes
2) Features indicating Holocene activity	Yes	Yes	Yes
3) Features indicating Quaternary activity	Yes	Yes	Yes
Estimated maximum magnitude earthquake	8.3	6.5	6.75-7.0
Remarks	Maximum displacement of 6m in 1906	Magnitude 5.7 earthquake in October 1969	Magnitude 3 to 4.5 earthquakes in 1969, 1971 and 1977

<u>CHARACTERISTICS</u>	<u>COLLAYCMI</u>	<u>BIG SULPHUR CREEK</u>	<u>KONOCTI BAY/ CHILDERS PEAK</u>
DISTANCE FROM SITE (km)	2		
MAPPED LENGTH (km)	About 40	6.4	About 30
TYPE OF FAULT	Right-lateral Strike-slip possibly some vertical component	Normal with possibly some right-lateral strike-slip	Normal, high-angle
ACTIVITY STATUS			
1) Historic activity	None known	None known, possibly small earthquakes	None known, but small earthquakes in area
2) Features indicating Holocene activity	None observed	Yes, also geomorphic features	Geomorphic features suggestive of faulting
3) Features indicating Quaternary activity	Yes	Yes	Yes
Estimated maximum magnitude earthquake	---	---	---
Remarks	Offset terrace gravels with clasts dated as 0.4 million years old.		Offset Quaternary volcanics of the Clear Lake sequence

Modified from Borchardt, 1975

Other potential sources of earthquakes include The Geysers Peak, Konocti Bay, and Porter Creek faults. Due to their distance from the site, and their limited size, associated historical seismicity, and geologic evidence of activity, these faults are no more likely to produce damaging levels of shaking in the steam field than presently unrecognized sources closer to the site.

Recent microseismic studies by the U.S. Geological Survey indicate that microseismic activity increases in areas of existing power plant facilities. A magnitude 5 earthquake is a reasonable upper bound for this anomalous "steam production" area.* On the assumption that the entire steam field will become a steam production area within the next decade, the seismic characteristics of the present steam production area probably represent the entire steam field.

LEASEHOLD GEOLOGY

The leasehold is generally underlain by rocks of the Franciscan assemblage with a blanket of Plio-Pleistocene volcanic rocks covering the Franciscan assemblage in the northern half of the leasehold. The exposed Franciscan assemblage in the southern portion of the leasehold reveals complex geologic structures which indicate a history of much faulting and folding. Faults crossing the northeast portion of the leasehold have displaced volcanic rocks which are probably Quaternary in age; the faults may therefore be potentially active.

ECONOMIC MINERAL DEPOSITS

The closest mine is the Socrates Mine, located near the ridge crest on the south side of Big Sulphur Creek about two miles southwest of the leasehold. This mine was developed for the extraction of mercury and is now inactive.

IMPACTS

GEOLOGIC HAZARDS

The Initial Environmental Impact Evaluation section shows potential geologic hazards which could credibly affect the leasehold and power plant. Geologic hazards, such as liquefaction, expansive and collapsible soils, tsunamis and seiches, are not likely to occur within the leasehold. However, earthquake shaking and landslides could potentially damage the power plant and/or related facilities, thereby resulting in potential adverse impacts to public health and the environment or forcing a plant shutdown. For example, rupturing of steam pipelines would result in unabated steam releases into the atmosphere, or collapse of transmission towers and transmission lines could start fires. These are examples of "indirect" impacts which may result from earthquake shaking or landslides. These geologic hazards are discussed in more detail below.

*Conclusion reached at October 25 and 26, 1979, Seismic Hazards Evaluation Methodology Workshop.

EARTHQUAKE SHAKING

Earthquake ground shaking results from energy release when movement occurs along faults in the earth's crust. Earthquake shaking affects large areas, but generally, structures can be designed to adequately withstand this phenomenon. Based on present geologic knowledge, California Energy Commission staff believes it unlikely that faults within The Geysers steam field will produce any large damaging earthquakes due to either natural or induced activity during the economic life of the proposed facilities. The strongest shaking at the proposed site would most likely be caused by one of the larger regional faults, such as the Maacama Fault.

Due to its proximity to the steam field and the magnitude of earthquake which may occur along it, the Maacama Fault is the most significant potential source of earthquakes. However, the potential ground shaking from earthquakes on the San Andreas and Rodgers Creek faults, from the steam production area, and from "random" seismic events not clearly associated with any source is also considered in evaluating seismic hazards for The Geysers power plant units.

LANDSLIDES AND SLOPE INSTABILITY

Landsliding and slope instability are among the most significant geologic problems facing development of The Geysers geothermal resource (Bedrossian, 1978). Landslides and unstable slopes may endanger facilities in three ways: (1) a surface facility sited at the base of an unstable slope may be buried by landslide material if upslope materials fail and encroach upon the structure; (2) a facility sited on an unstable slope may be pulled downhill and torn apart if the underlying materials are involved in a landslide; and (3) a subsurface facility (such as a well) may be sheared off, torn apart, and/or severely deformed below the surface if it is sited on unstable materials at or near the ground surface. In the case of geothermal steam wells, such an event usually results in well blowouts at the surface.

FAULT RUPTURE

Faults which displace Quaternary volcanic rocks, and are therefore potentially active, cross the leasehold. It is not likely that these faults would rupture due solely to natural causes during the lifetime of the reservoir. However, subsidence induced by reservoir depletion may focus along such faults. This could rupture facilities intersected by the faults.

IMPACTS ON GEOLOGIC ENVIRONMENT

Potential impacts on the geologic environment include effects on local fumaroles and hot springs, on the steam reservoir itself, and inducement of landsliding, subsidence, and seismicity. Other impacts on commercial geologic resources (e.g., ores, fossil fuels, gems, which may be commercially exploited by mining, quarrying, or drilling) or on noncommercial geologic resources (e.g., caves, mineral collecting localities) which are of recreational or scientific interest in the vicinity of the proposed project are not considered significant by CEC staff.

MITIGATION MEASURES

EARTHQUAKE SHAKING MITIGATION

The proposed facilities can be designed to adequately withstand seismic shaking. Wells and transmission lines are relatively insensitive to seismic shaking and probably require no special treatment except properly sited (i.e., sited on stable ground) and engineered well pads and tower footings. Because of their flexibility, properly constructed transmission lines and pipelines should suffer little damage, even by severe shaking. If damaged, they can usually be quickly repaired.

Occidental proposes to use a seismic design which will ensure that the power plant will be out of operation for only about a week should a peak bedrock acceleration of 0.15g occur at the site. Based on probabilistic seismic hazard analysis performed for other generating units at The Geysers (Shah, 1980), the probability of exceeding this acceleration at the site in a 30-year facility lifetime is about 25 percent.

LANDSLIDE AND SLOPE INSTABILITY MITIGATION

CEC staff believes that the power plant facilities will not be endangered by landsliding. Landslides have been mapped within the leasehold, but none appear within the mapped power plant site. The generating unit, cooling towers, and H₂S abatement system will be located on bedrock, undisturbed by landslides.

FAULT RUPTURE MITIGATION

The power plant site is set back far enough from the faults that no damage due to fault rupture is expected. Of the other facilities, only damage to steam wells is considered significant (due to potential blowout of damaged wells). To minimize blowout potential, geothermal wells should be drilled so that they do not intersect such faults within 500 feet of the ground surface.

SOILS

SETTING

METHODOLOGY

Soil mapping of the Occidental leasehold (Soils Figure 1) was based mainly on unpublished material on file with the Soil Conservation Service (SCS) at the Soil Survey Office located in Lakeport, California.^{1*} A small portion of the lease is covered in the Sonoma County Soil Survey.² Refinements were based on additional aerial photo interpretation and a field reconnaissance by WESCO. A literature review of published geologic and soils information was also completed by Occidental. Sources consulted included Brice (1950),³ California Division of Mines and Geology (1946),⁴ McLaughlin (1974),⁵ McNitt (1968a),⁶ and Miller (1972).⁷

EXISTING CONDITIONS

Occidental's proposed lease area reposes on steep, upland terrain on the crest of the Mayacmas Mountains. Slopes tend to be very steep near Cobb Mountain and the ridgeline. Some gentler slopes occur on and around the serpentine area and on the rounded ridge between Anderson and Gunning creeks (Figure 1).

Because of the complex bedrock geology of the area, single soil series were not mapped separately. Soil complexes were delineated by land types. The strong interrelationships between the soils and the geologic parent materials allow discussion of the soils by relating them to four landform units. These lithologic units include (1) serpentinitic rocks south of Anderson Creek, (2) rhyolitic rocks on uplands south of Cobb Mountain, (3) a stabilized landslide of mostly rhyolitic rock origin between Anderson and Gunning creeks, and (4) a large area of shale and graywacke of the Franciscan assemblage.

Serpentine Uplands

Henneke and Montara soils are the principal soils formed on the serpentine landform. These soils are shallow and generally infertile and typically support a sparse brush cover. They occur as an elongated body on a midslope position in this area. Erosion hazard is high. A magnesium-calcium imbalance greatly reduces revegetation potential by impairing calcium uptake. Erosion control and revegetation in these areas often require the use of topdressing and fertilization to establish cover.

Rhyolitic Uplands

Kidd, Forward, Forward Variant, and Etsel soils are the principal soils formed on fractured rhyolite. Depth varies from shallow to very deep over short distances due to variability in weathering. Slopes are generally very steep. Vegetation is mostly scattered conifers with a brush understory. In general, this landform type presents the least problems in terms of slope stability, erosion, and revegetation. Local problems of revegetation can occur on shallow south-facing soils.

*References for this section are located at the end of the Soils section.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

LEGEND

- 145 HENNEKE-MONTARA-ROCK OUTCROP
COMPLEX, 15 TO 50 PERCENT SLOPES.
- 166 FORWARD VARIANT-KIDD COMPLEX
30 TO 50 PERCENT SLOPES.
- 170 KIDD-FORWARD COMPLEX
5 TO 30 PERCENT SLOPES.
- 389 HARBIN-WHISPERING COMPLEX
30 TO 50 PERCENT SLOPES.
- 534 MAYMEN-HOPLAND-WOODIN ASSOCIATION
30 TO 50 PERCENT SLOPES.
- 534S MAYMEN-MONTARA COMPLEX
15 TO 30 PERCENT SLOPES.
- 536V ROCK OUTCROP-ESTEL COMPLEX
80 TO 90 PERCENT SLOPES.
- 541 MAYMEN-ESTEL COMPLEX
30 TO 50 PERCENT SLOPES.

FIGURE 1: SOILS-Leasehold Soils Map

Stabilized Landslides

Harbin and Whispering soils are the principal soils associated with the stabilized landslide and deeper colluvial soils found along the eastern edge of the proposed project area. Geologic parent material is dominantly volcanic, with graywacke and shale in local areas. Although potential timber productivity is high, the dominant cover is dense brush with a sparse hardwood overstory. Conifers are found only in protected pockets. This reflects the history of fire in this area as well as high summer temperatures, which hinder regeneration. The soils of this landform type are generally more erodible and unstable, but successful revegetation is usually less difficult than on the other three land forms.

Sandstone and Shale Uplands

Maymen, Hopland, Woodin, and Etsel soils are the principal soils found on hard and fractured shale and graywacke of the Franciscan assemblage. Shallow soils with high erosion hazards are intermingled with moderately deep soils with moderate erosion hazard as a result of complex residual and colluvial patterns. The cover is brush with a density and composition reflecting variations in potential productivity. The soils are generally gravelly with low levels of fertility.

SOIL CHARACTERISTICS

Soil interpretations are presented in Table 1, Soils Appendix D. Much of this information relates to assessing erosion. The most up-to-date information for the area originates from the SCS. This information emphasizes use of the Universal Soil Loss Equation (USLE) in predicting erosion (Evans, 1976; Osborn, 1976; Soil Conservation Service, 1975; and Wischmeier, 1976).^{8,9,10,11}

The composition and associated characteristics of the soil map units are presented in Soils Appendix D, Tables 2, 3, and 4. This appendix provides information for evaluating the productivity, fertility, and revegetation potential of the soil complexes. Appendix A also provides an assessment by the SCS of various habitat elements and the suitability for four habitat types. Four soils provide good potential for woodland habitat; no soil rates better than fair as a rangeland habitat.

IMPACTS

During construction of the access road, power plant, and transmission line accelerated erosion may occur due to soil disturbance and the removal of the vegetative cover. Fill areas tend to be more susceptible to erosion than cut areas. Erosion may persist in the vicinity of culverts, cuts, and fills. After construction, a three-year period of stabilization should lead to an eventual return to near preconstruction rates.

The proposed power plant is located on gentle to moderately steep slopes and on thin, infertile soils with high erosion potential. (The Hydrology Section includes a discussion of erosion rates.) These soils overlie bedrock which will be exposed on the sites and will form a large portion of the fill material.

Soil productivity is limited because of shallowness, the type of parent material, poorly distributed rainfall, and extremely high summer temperatures. Special effort will be necessary in reestablishing vegetation on droughty, south-facing slopes.

There are no existing agricultural uses on the Oxy leasehold nor is there any potential for such uses. The capabilities of the soils on the leasehold limit their use to grazing by domestic animals and wildlife and the growth of timber and woodland vegetation. The prime use of the area is to support wildlife and serve as a watershed for the community of Anderson Springs. As such, the Occidental project will have no impact on prime soils or the area's potential for agricultural production.

MITIGATION MEASURES

Several techniques are available for erosion control within the leasehold. Good erosion control is dependent upon proper engineering of cut slopes, fill slopes, and drainage systems. Cut slopes should be no steeper than 1.5:1 where conditions allow. These cut slopes shall be left as rough as possible to allow for seed and moisture catch points. In addition, long cut slopes should be terraced to visually soften the cut slope when viewed from a distance. Fill slopes shall be no steeper than a 2:1 gradient. Berms and interceptor ditches shall be provided to divert over the slope water away from all freshly graded slopes. Flow from these ditches shall be directed to the sedimentation pond, which is expected to trap sediment emanating from the graded slopes.

Erosion control seeding methodology shall be site specific. Hydroseeding has proven to be an effective method of applying seed, fertilizer, and mulch. However, on coarse-textured fill slopes, broadcast seeding with coated seed and pelleted mulch may prove to be more effective. Final locations for each method should be reviewed following the completion of grading operations.

Timely application of erosion control materials is important for good germination and subsequent vegetation establishment. All erosion control work (grading, drainage, riprap, and seeding) will be completed prior to November 1 of the construction year, if construction is allowed to start as scheduled.

In addition to these erosion control measures, several additional preventive measures are also suggested. These are as follows:

- o Construction activities will be restricted to the smallest area feasible.
- o Earthmoving activities will be suspended during high precipitation periods, typically December through March, to avoid disturbance during the months of high intensity storms.
- o A buffer zone of 250 feet (76 m) on each side of the stream will be established in which no ground disturbance will be allowed.
- o Filling operations will take place during the dry season, leaving adequate time before the heavy rains of late fall and winter for hydromulch

seeding of exposed soil to sprout and establish itself. The establishment of vegetative ground cover prior to the rainy season can be promoted by irrigating the hydromulch.

- o Revegetation efforts will take into account the low fertility of the soils involved. Topsoil will be stockpiled and replaced after construction. Fertilization and mulching will be provided and vegetative cover will be established on disturbed areas prior to the arrival of winter storms.
- o Dust will be controlled through surfacing the access road or at least regular watering.
- o A long-range fire management plan will be developed to accommodate the increase in fire hazard plus the historic trends toward natural fire in the region.
- o Temporary erosion control measures will be used during the construction of cut and fill slopes, the foundations, and grading operations at the site by directing the surface runoff away from the disturbed areas, by stabilizing the soil stock pile, and by establishing vegetative cover.
- o Cut slopes will be terraced to reduce sheet erosion, to dissipate runoff velocity, and to provide favorable sites for revegetation.
- o Runoff from the cut slopes will flow through a series of check dams or sediment ponds which will collect material eroding from the slope.
- o The plant site shall be bermed to control accidental spills.

MONITORING PROGRAM

The Oxy Geothermal Plant No. 1 monitoring program will begin just prior to the onset of plant and access road construction (spring 1982), and it shall continue for four years (through 1986). Baseline data for the site has been collected and is reported in the AFC. A schedule for implementing the mitigation plan is shown in Table 5, and the schedule for the monitoring program is presented in Table 6. Monitoring methodologies are briefly discussed as follows:

Erosion, Sediment, and Spill Control Monitoring

The site sediment control system will be checked every spring following the rainy season and again in the fall. Ditches will be cleaned as necessary at these times. The sedimentation pond will be checked once a year at the end of the rainy season, and it will be cleaned when nearing its full capacity. Occidental's proposal to gravel access roads is not adequate to control sediment deposition in Anderson Creek. As pointed out earlier, Occidental should pave their access roads and the associated borrow pits and berms.

Occidental should be required to monitor the soil losses from fill slopes by keeping track of the tons of sediment removed from drain ditches and/or by the placement and periodic reading of slope stakes.

Pre-, during, and postproject photographs should be taken by Occidental to indicate the impacts of their construction on the soils water resource. Occidental should take photographs after mitigation practices have been established to indicate the effectiveness of such practices to protect the soils and waters of the Anderson Creek watershed.

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HYDROLOGY

SETTING

WATERSHED DESCRIPTION

Occidental leasehold, CA 5636 and CA 5637, is located on the south face of Cobb Mountain along the ridgeline between Lake and Sonoma counties, California. The 7.4 acre plant site will be located in Lake County. Water Figure 1 shows major stream systems within the 550 acre leasehold. Drainage basin boundaries in the vicinity of the leasehold appear on Water Figure 2.

Surface flow from 90 percent of the leasehold drains south and east into Putah Creek via Anderson and Gunning creeks. Runoff from the remainder of the leasehold flows south and west into Big Sulphur Creek.

Anderson Creek, a tributary of Putah Creek, drains 380 acres or 73 percent of the leasehold. Eighty-five acres in the northeastern corner of the leasehold drain into Gunning Creek, a tributary of Anderson Creek. Tributaries of Big Sulphur Creek drain a thin 85 acre slice along the western boundary of the leasehold in Sonoma County.

Anderson Creek is a perennial stream with a total drainage of 8.8 square miles above its confluence with Putah Creek. Gunning Creek, which is also perennial, drains 1.3 square miles upstream from its junction with Anderson Creek. Big Sulphur Creek dissects The Geysers KGRA as it flows northwest to its confluence with the Russian River. Along its course Big Sulphur Creek drains 82 square miles¹ (WRI 77-21) of the western slope of the Mayacmas Mountains before emptying into the Russian River at Cloverdale (USGS Gage 11-4632). Table 1 lists drainage areas for the various streams and tributaries in the vicinity of the leasehold.

Dry Creek near Middletown (USGS 11-4532) contains the closest stream gaging station suitable for correlation with peak runoff from Anderson and Gunning creeks.² Streamflow records at this station were collected for 13 years between 1959 and 1972.³ The drainage area above the station contains 8.35 square miles.⁴

PRECIPITATION

The majority of precipitation in the site vicinity occurs during the late fall and winter months. Rantz and Thompson (1967)⁵ reported that about 80 percent of the annual precipitation falls during the period November to March. The bulk of the rain comes during intense storms of relatively short duration. Snow falls occasionally on the leasehold, but the snow cover seldom lasts for more than a few days.

Precipitation in the vicinity of the site is measured at "The Geysers" (National Weather Service Station No. F90-8885). The rain gage is located 4.5 miles west of the site at an elevation of 1,668 feet.⁶ Mean annual precipitation for 38 years of record is 56.94 inches. Normal snowfall for the area averages 20 inches per year.⁷

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 1: WATER-Area Streams

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

LEGEND

No.	NAME
I	PUTAH CREEK ABOVE ANDERSON CREEK
II	GUNNING CREEK
III	ANDERSON CREEK ABOVE PUTAH CREEK
IV	BEAR CANYON CREEK

FIGURE 2: WATER-Drainage Basins Near the Leasehold Area

WATER TABLE 1
DRAINAGE AREA OF STREAMS IN SITE VICINITY

<u>Stream Description</u>	<u>Drainage (sq mi)</u>	<u>Area (ac)</u>
Anderson Creek upstream of Putah Creek	8.8	5632
Bear Canyon Creek upstream of Anderson Creek	3.3	2112
Anderson Creek upstream of unnamed tributary	3.5	2240
Gunning Creek upstream of Anderson Creek	1.3	832
Unnamed tributary upstream of Anderson Creek	0.8	512
Anderson Creek upstream of leasehold boundary	0.5	320
Gunning Creek upstream of leasehold boundary	0.3	192
Leasehold area within Big Sulphur Creek Basin	0.1	64
Putah Basin Creek upstream of Anderson Creek	4.9	3136

Source: Calculated from USGS The Geysers and Whispering Pines 7 1/2" Quadrangles

WATER TABLE 2
HIGHEST RECORDED ANNUAL PRECIPITATION
(1940 - 1974)

<u>Item</u>	<u>Duration (hr)</u>							
	<u>1/4</u>	<u>1/2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>	<u>12</u>	<u>24</u>
Highest Annual Precipitation at Station 8885 (depth in inches)	0.92	1.25	1.74	2.03	2.48	3.74	5.91	9.58
Transposition Ratio	1.22	1.22	1.22	1.27	1.32	1.36	1.38	1.41
Transposed Highest Annual Precipitation at Occidental Site (depth in inches)	1.12	1.53	2.12	2.58	3.27	5.09	8.16	13.51
Record Year	1958	1958	1958	1966	1966	1962	1940	1955

Water Table 2 shows maximum annual precipitation at "The Geysers" for specified durations. These values represent the highest recorded during the period 1940 through 1974.⁸ Annual precipitation at the plant site is approximately 80 inches, based on a mean annual precipitation map prepared by Rantz in 1969.⁹

Water Table 2 presents comparable values for the leasehold. Oxy consultants developed the values using the Rantz method for transposing recorded precipitation data from one site to another, based on the ratio of mean annual rainfall at the sites.¹⁰ Water Table 3 describes frequency-intensity-duration data for the site area for various return periods.

Probable Maximum Precipitation (PMP)

Storms in the site area are generally either the frontal-type general storm which occurs from October through April or the convective-type thunderstorm which occurs during the summer and early fall. Values for the one square mile Probable Maximum Thunderstorm (PMT) for the site area appear in Water Table 4. The equivalent winter Probable Maximum Precipitation (PMP) monthly values are given in Water Table 5.

RUNOFF

The leasehold is located on the south face of Cobb Mountain. The plant site and Drill Pad A repose on a northwest to southeast trending ridge line, while Drill Pads B and D sit on the nose of ridges extending south from Cobb Mountain. All four sites are situated well above nearby streams and possess little upstream drainage. Therefore, CEC staff anticipates that the only runoff would come as the result of direct precipitation.

Such is not the case for Drill Pad C, which will be partially located in an arroyo tributary to Anderson Creek. The drill pad fill will intercept runoff from approximately seven acres. Placement of the fill will cover and reorient the flow of an existing spring.

The transmission towers are not subject to flooding because of their elevated position. Generally, the same is true of the access roads. An exception would be where the access road from site C to B crosses Anderson Creek. Steam lines will not be vulnerable to flooding as long as the crossings of Anderson Creek are properly designed and situated.

Rainfall intensity and duration, ground slope, vegetative cover, and soil conditions govern the amount of surface runoff. Ground slope in the leasehold is relatively steep (0.5 ft/ft or 50 percent) with the steepest slopes in the northwest portion of the leasehold. Five hundred cfs is expected to runoff the 470 acres in the Anderson Creek drainage during the 1:100 flood. CEC staff calculated the 500 cubic feet per second (cfs) using flood frequency equations developed by Waanen and Crippen¹¹ for the North Coast Region and developed 1:100 runoff quantities for the gaging station on Dry Creek near Middletown (Gage No. 11-4532).

WATER TABLES

Table 3
RAINFALL FREQUENCY - DURATION
(Point Values of Accumulated Rainfall Depth in Inches -
from Annual Records)

Return Period (yr)	Duration (hr)						
	<u>1/2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>	<u>12</u>	<u>24</u>
1	0.5	0.6	1.2	1.7	2.7	4.0	5.1
2	0.6	0.8	1.4	1.8	3.0	5.0	7.2
5	0.8	1.0	1.6	2.1	3.6	6.4	9.4
10	0.9	1.1	1.8	2.4	4.0	6.8	10.6
25	1.0	1.3	2.0	2.7	4.7	8.4	12.0
50	1.1	1.5	2.3	3.2	5.2	9.4	13.7
100	1.3	1.6	2.5	3.4	5.8	10.4	15.4

Source: Miller, Frederick, and Tracey. 1973.

Table 4
THUNDERSTORM PMP DEPTH - DURATION
(1 sq mi)

	Duration (hr)					
	<u>1/4</u>	<u>1/2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>
Accumulated Depth (inches)	2.4	4.0	6.0	7.9	9.1	10.5

Table 5
WINTER STORM PMP - DURATION
(1 sq mi, Depth in Inches)

<u>Month</u>	<u>1/2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>	<u>24</u>
Oct.	2.8	4.0	5.2	8.1	12.6	31.7
Nov.	2.7	3.8	5.0	7.7	12.3	32.1
Dec.	2.5	3.6	4.7	7.6	12.1	32.8
Jan-Feb.	2.4	3.5	4.6	7.4	12.0	33.2
Mar.	2.4	3.4	4.4	7.2	11.8	32.1
Apr.	2.4	3.4	4.4	7.1	11.3	30.1

Source: Hansen, Schwarz, and Riedel, 1971.

FLOOD HAZARD

There is little likelihood of flooding at the plant site or drill sites A, B, C and D because of their elevated position and limited upstream drainage. However, the removal of existing vegetation and scalping of soils will increase the runoff from an additional 63 acres in The Geysers KGRA. The replacement of natural terrain, soils, and plant cover with buildings, paved lots, and denuded slopes will decrease infiltration and lag time and increase velocity, peak flows, and runoff volume from the affected areas.¹² Because of the small acreages involved, there would be little regional impact.

This project alone would not increase the flood hazard to downstream residents. The 45 acres slated for disturbance in the Anderson Creek watershed amount to less than 1 percent of the drainage area. However, the continued development of plant sites, roads, and drill pads could result in higher runoff, flooding, and sediment deposition within the Anderson Creek watershed.

EROSION, SEDIMENT YIELD, AND SEDIMENT TRANSPORT

Erosion

Rainfall in The Geysers area is known for its highly erosive nature. The highest recorded rainfall at The Geysers exceeded the 1:1000 recurrence interval for rainfall received during 15 and 30 minute durations and also for the 1:200 one-hour storm.¹² Storms of high intensity and short duration are expected during the life of the Occidental power plant.

Soils underlying the leasehold erode badly when exposed to direct rainfall and overland flow (see Soils section). Natural ground slopes in the leasehold range from 20 to 100 percent. Ground cover consists mainly of brush, annual and perennial grasses, and scattered coniferous trees. Taken together, intense rainfall and erodible soils could lead to accelerated erosion on the leasehold.

Sediment Yield

CEC staff used the Universal Soil Loss Equation¹³ to estimate annual soil losses due to sheet erosion on a pre-, during-, and post-construction basis. They used composite soil erodibility factors (K) in the equation which were taken from the Occidental AFC. Annual preproject erosion was estimated to be 3.2 tons per acre. During construction when soil surfaces are fully exposed on steep slopes, erosion losses could increase to more than 200 tons per acre. Occidental's proposed mitigation measures should reduce soil losses from fill slopes to six tons per acre, which is still twice the recommended rate of 3 tons per acre per year.

Waterborne sediment from the leasehold eventually finds its way into Putah Creek and Lake Berryessa via Anderson and Gunning creeks. The majority of suspended sediment is transported during the period November through March, which corresponds with the period of heaviest rainfall, greatest runoff, and highest erosion potential. Experience has shown that 90 percent or more of the annual sediment yield may occur in 1 or 2 days of flood flow.¹⁴ The USGS gaging station on Putah Creek near Guenoc recorded levels of total suspended solids for the water years 1962 through 1973. Daily records were taken from

December 1964 through 1965. A summary of these records appears in Water Table 6. During this very high runoff period, the mean sediment concentration exceeded the "nondrinkable" level (27 mg/l)¹⁵ on 24 days. In 1965 two geothermal plants in the KGRA produced only 24 megawatts of electricity. Presently this known geothermal resource area contains 15 sites with a total output of 908 megawatts. Therefore, the sediment loads do not reflect the potential disturbance due to geothermal development in the Putah Creek Watershed. On the other hand, sediment loads carried by Northern California streams during the very wet 1964-65 water year were probably two to five times as great as would normally be expected.¹⁶

Brown and Caldwell¹⁷ recently completed a study of the Anderson Springs water gathering system on behalf of Occidental Geothermal, Inc. Based on existing records and data collected by them, they found water quality downstream from the Occidental leasehold to be generally good, with occasional high values for turbidity, iron, manganese, chromium, sulfate, and total dissolved solids.

They concluded that after heavy rainfall, water supplied by the Anderson Springs Water Company may violate California Department of Health Services criteria for turbidity. Increases in suspended solid concentrations were observed in Gunning Creek at the Ford Flat Road crossing after locally heavy rainfall. See Water Table 7.

Between March 1978 and February 1980, PGandE and Aminoil, Inc., conducted a two-year water quality monitoring program of the Upper Putah Creek drainage basin. This program consisted of monthly sampling during the first year and quarterly sampling the second (Water Table 8). Based on the one year of data, the interim report for the first year of the two-year water quality monitoring program contained some interesting insights into the relative water quality of streams in the Anderson Creek drainage basin.¹⁸

Only those tributaries of Anderson Creek which could be influenced by activities on the Occidental Leasehold have been included. See Figure 3 and Table 8.

It was noted that the water quality characteristics of Anderson Creek change as it flows towards its mouth due to inflow from several tributaries. Inflow from the intermittent tributary which flows from PGandE's Unit 13 along the Socrates Mine Road contributed both dissolved and suspended solids during runoff periods. This inflow resulted in increased specific conductance and higher turbidity. Further downstream, the high quality inflow from Gunning Creek caused a noticeable drop in specific conductance, total dissolved solids, and sulfates in Anderson Creek.

Water Table 9 also summarizes the number of turbidity samples taken (16) and the number of those samples which exceeded the corresponding maximum contaminant level (MCL).^{*} Nine of the samples taken for the five stations exceeded

^{*}"MCL" is the level of contaminant which, if exceeded, would present a risk to the health of humans when used continually for drinking or culinary purposes. These standards are contained in the "California Domestic Water Quality and Monitoring Regulations," Title 22, CAC.

WATER TABLE 6

SUSPENDED SEDIMENT - PUTAH CREEK NEAR GUENOC, CALIFORNIA

~~December 1964 to March 1965~~

Loads are estimated where no concentrations are reported.

DECEMBER

JANUARY

SUSPENDED SEDIMENT

SUSPENDED SEDIMENT

DAY	MEAN DISCHARGE (cfs)	MEAN CONCENTRATION (ppm)	TONS PER DAY	DISCHARGE (cfs)	MEAN CONCENTRATION(ppm)	TONS PER DAY
1	74	----	0.4	709	----	23
2	76	----	0.4	1210	210	1800
3	61	----	0.2	3310	425	4280
4	53	----	0.1	2910	339	3630
5	50	----	0.1	10100	1890	64000
6	45	----	0.1	4660	949	12600
7	42	----	0.1	2490	346	2520
8	40	----	0.1	1410	110	419
9	38	----	0.1	1000	33	89
10	36	1	0.1	787	20	42
11	43	----	0.2	689	----	30
12	42	----	0.2	568	----	21
13	36	----	0.2	467	----	18
14	34	----	0.2	400	----	15
15	35	----	0.2	354	----	12
16	33	----	0.2	308	----	11
17	31	----	0.2	282	----	9.1
18	31	----	0.2	256	12	8.3
19	229	39	35	242	----	7.2
20	983	244	850	229	----	6.2
21	7230	1240	30700	208	----	4.5
22	14800	1580	67000	194	----	2.6
23	6930	866	18800	1340	459	4190
24	2630	438	3450	1580	119	598
25	1270	108	392	745	27	54
26	2300	515	5000	545	16	24
27	2160	241	1500	439	----	17
28	1370	62	229	377	----	12
29	1230	46	153	311	----	8.9
30	1140	37	114	296	----	6.4
31	991	25	67	272	----	5.1
TOTAL	44063	----	128293.3	38708	----	94463.3

Source: USGS 1965. "Quality of Surface Waters of the United States," Parts 9 through 11, Colorado River Basin to Pacific Slope Basins in California.

WATER TABLE 6 (con't)

SUSPENDED SEDIMENT - PUTAH CREEK NEAR GUENOC, CALIFORNIA

December 1964 to March 1965

Loads are estimated where no concentrations are reported.

FEBRUARY

MARCH

SUSPENDED SEDIMENT

SUSPENDED SEDIMENT

DAY	MEAN DISCHARGE (cfs)	MEAN CONCENTRATION (ppm)	TONS PER DAY	DISCHARGE (cfs)	MEAN CONCENTRATION(ppm)	TONS PER DAY
1	249	----	4.0	101	----	0.8
2	227	----	3.1	98	----	0.8
3	210	----	2.3	93	----	0.8
4	208	----	2.8	90	----	0.7
5	532	35	55	90	----	0.7
6	331	9	8.0	95	3	0.8
7	260	----	3.5	92	----	0.7
8	331	----	3.6	86	----	0.7
9	212	----	1.7	83	----	0.4
10	194	----	1.0	82	----	0.4
11	182	2	1.0	82	2	0.4
12	173	----	0.9	81	----	0.4
13	----	----	----	78	2	0.4
14	157	----	0.8	76	----	0.4
15	148	----	0.8	75	----	0.4
16	141	----	0.8	72	----	0.4
17	134	----	0.7	71	----	0.4
18	128	----	0.7	69	----	0.2
19	125	----	0.7	67	----	0.2
20	120	----	1.0	64	----	0.2
21	115	3	0.9	62	----	0.2
22	114	----	0.9	61	----	0.2
23	109	----	0.9	60	----	0.2
24	104	----	0.8	58	----	0.2
25	102	----	0.8	57	----	0.2
26	99	----	0.8	60	----	0.2
27	131	3	1.1	203	32	24.
28	109	----	0.9	118	----	2.2
29	----	----	----	92	----	1.2
30	----	----	----	86	----	0.9
31	----	----	----	86	----	0.7
TOTAL	5007	----	100.4	2588	----	40.4

WATER TABLE 7
 RAINFALL AND SUSPENDED SOLIDS DATA FOR
 SPOT SAMPLING OF GUNNING CREEK - 1980-81

Date	Rainfall, ^a Inches	Suspended solids, mg/l	
		Gunning Creek	Tributary
12-12	0.00	<0.4	1
12-21	4.65	2	0.4
12-22	0.00	0.4	<0.4
12-23	0.00	0.4	<0.4
12-24	0.00	1	<0.4
1-16	0.87	0.7	4
1-17	0.79	0.4	4
1-18	0.00	<0.6	0.7
1-19	0.68	2	0.7
1-20	0.63	0.7	0.4
1-22	0.20	2.5	13
1-23	1.59	4.6	5.1
1-24	0.01 ^b	1.4	1.1
1-25	0.00	1.3	1.5
1-26	1.30	1.1	0.8
1-27	3.91	7.4	8.2
1-28	0.81 ^b	4.4	4.9
1-29	0.20	3.2	1.5
1-31 ^c	0.01	2.7	0.9
2-1	0.00	1.8	1.1

^aRainfall data taken at PGandE Power Plant 13, located about 2,300 meters south and 200 meters higher than the water quality monitoring stations.

^bSome rainfall data lost due to rain gage malfunction.

^cNo suspended solids samples taken on January 30, 1981, owing to snow which prevented site access.

WATER TABLE 8a
WATER QUALITY CHARACTERISTICS AT STATION A2.7, 1977-1980

Characteristic	Units	3/6/78	4/4/78	5/1/78	6/8/78	7/5/78	8/1/78	9/6/78	10/4/78	11/7/78	12/5/78	1/3/79	2/5/79	5/8/79	8/22/79	11/7/79	2/4/80
Steam Flow	gpm	11,100	9,300	2,370	950	1,200	200	730	50	46	177	120	1,170	3,320	310	1,700	1,900
Water Temperature	°C	10.5	9.5	13.0	18.5	17.0	20.0	15.0	14.0	11.5	7.0	6.0	6.0	10.5	13.5	12.0	10.5
pH		8.1	8.0	7.8	7.9	7.9	7.5	7.5	7.3	7.3	7.2	7.7	7.8	7.8	7.4	8.0	7.9
Specific Conductance	umho/cm	142	163	179	181	163	150	146	149	132	183	158	204	181	150	209	167
Turbidity	JTU	1.90	6.30	0.60	0.30	0.20	0.40	0.30	1.30	0.30	1.30	1.00	1.00	1.80	0.33	7.8	1.2
Total Dissolved Solids	mg/l	73	116	96	164	86	86	102	110	108	116	76	123	94	103	116	100
Total Suspended Solids	mg/l	4.0	4.6	0.8	1.6	2.0	0.8	0.8	12.0	<0.8	4.4	2.8	183	1.6	1.2	3.8	2
Chemical Oxygen Demand	mg/l	—	<5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved Oxygen	mg/l	10.6	10.6	9.9	8.5	8.6	7.8	8.7	9.0	9.6	10.7	13.4	11.0	11.0	9.4	9.8	9.9
Alkalinity	mg/l as CaCO ₃	65	—	—	82	—	—	67	—	—	78	—	—	89	72	98	78
Hardness	mg/l as CaCO ₃	62	—	—	76	—	—	59	—	—	70	—	—	92	65	99	76
Oil and Grease	mg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ammonia, Total	mg/l as N	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	0.01	0.09	<0.05
Ammonia, Unionized	mg/l as NH ₃	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	—	—	—	—
Nitrate Nitrogen	mg/l as N	<0.01	0.01	0.02	0.08	<0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.01
Nitrite Nitrogen	mg/l as N	<0.002	<0.004	0.004	<0.004	<0.004	<0.004	0.004	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.001	0.005	0.001
Sulfate	mg/l	3.8	4.1	5.1	4.4	4.2	3.7	3.9	3.7	4.3	6.3	5.9	6.9	5.1	2.8	8.6	4.7
Sulfides	mg/l	<0.008	<0.007	<0.009	<0.005	<0.030	<0.005	<0.010	<0.010	<0.020	<0.030	<0.020	<0.160	—	—	—	—
Aluminum	mg/l	<0.1	—	<0.1	—	<0.1	—	<0.1	—	0.1	—	0.1	—	0.1	0.1	1.0	0.1
Arsenic	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Boron	mg/l	0.16	0.11	<0.10	<0.10	<0.10	0.14	<0.10	—	0.10	0.18	<0.10	0.20	0.01	0.15	0.10	0.10
Cadmium	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Copper	mg/l	<0.001	—	0.003	—	0.004	—	0.002	—	<0.001	—	<0.001	—	—	0.005	—	—
Chromium	mg/l	0.00	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	0.038	<0.001	0.015	<0.001
Iron	mg/l	0.27	—	0.08	—	<0.02	—	0.17	—	0.17	—	0.20	—	0.05	<0.01	0.66	0.22
Lead	mg/l	<0.001	—	<0.001	—	<0.001	—	0.003	—	<0.001	—	0.005	—	<0.001	<0.001	0.010	0.006
Mercury	mg/l	0.05	—	<0.02	—	<0.02	—	<0.02	—	<0.02	—	0.30	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	mg/l	0.003	—	0.004	—	<0.001	—	0.004	—	0.007	—	0.018	—	0.004	0.019	0.022	0.002
Selenium	mg/l	<0.002	—	—	<0.002	—	—	<0.002	—	—	<0.002	—	—	—	—	—	—
Vanadium	mg/l	<0.1	—	—	—	—	—	<0.1	—	—	—	—	—	—	—	—	—
Zinc	mg/l	0.005	—	0.001	—	<0.001	—	<0.001	—	0.007	—	0.013	—	0.020	0.026	0.005	0.001

Sources: Brown and Caldwell, 1979 and 1980; PGandE, 1979.

WATER TABLE 8b

WATER QUALITY CHARACTERISTICS AT STATION A2.8, 1977-1980

Characteristic	Units	3/6/78	4/4/78	5/1/78	6/8/78	7/5/78	8/1/78	9/6/78	10/9/78	11/7/78	12/5/78	1/3/79	2/5/79	5/8/79	8/22/79	11/7/79	2/4/80
Steam Flow	gpm	11,700	8,800	1,710	920	330	140	630	70	42	120	100	670	2,220	200	1,100	1,400
Water Temperature	°C	10.5	9.8	13.0	18.0	17.0	19.5	14.5	14.0	11.5	7.5	6.0	6.0	10.5	13.5	12	10.5
pH		8.1	7.8	7.6	7.9	7.8	7.5	7.5	7.3	7.5	7.2	7.6	7.7	7.7	7.3	7.9	7.9
Specific Conductance	umho/cm	120	148	147	159	148	150	147	148	124	161	133	163	160	145	180	143
Turbidity	JTU	1.60	2.40	0.50	0.25	0.20	0.40	0.30	0.30	0.30	0.35	0.25	0.50	0.35	2.7	0.65	0.75
Total Dissolved Solids	mg/l	94	92	72	152	88	82	106	112	114	92	86	108	89	99	116	101
Total Suspended Solids	mg/l	1.7	2.4	0.8	<0.8	0.8	0.8	<0.8	0.8	<0.8	2.8	<0.8	2.0	<0.8	1.2	1.2	<1
Chemical Oxygen Demand	mg/l	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved Oxygen	mg/l	10.0	10.6	9.9	8.6	8.8	7.7	8.8	9.0	9.6	10.7	13.2	12.0	11.0	9.2	9.8	10.0
Alkalinity	mg/l as CaCO ₃	53	—	—	70	—	—	68	—	—	68	—	—	77	70	82	64
Hardness	mg/l as CaCO ₃	51	—	—	64	—	—	58	—	—	60	—	—	77	64	80	64
Oil and Grease	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammonia, Total	mg/l as N	0.05	<0.05	<0.05	0.06	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	0.01	<0.01	<0.05
Ammonia, Un-ionized	mg/l as NH ₃	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	—	—	—	—
Nitrate Nitrogen	mg/l as N	<0.01	0.01	0.01	0.06	<0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Nitrite Nitrogen	mg/l as N	0.003	<0.004	0.004	<0.004	0.004	<0.004	0.004	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.001	0.003	<0.001
Sulfate	mg/l	3.4	3.9	4.8	3.9	3.2	4.0	3.9	4.1	4.1	7.0	4.9	6.2	4.6	2.9	6.1	4.2
Sulfides	mg/l	<0.008	<0.007	<0.005	<0.005	<0.010	<0.008	<0.010	<0.010	<0.020	<0.010	<0.010	<0.020	—	—	—	—
Aluminum	mg/l	0.2	—	<0.1	—	<0.1	—	<0.1	—	<0.1	—	<0.1	—	<0.1	<0.1	0.2	<0.1
Arsenic	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Boron	mg/l	0.14	<0.10	<0.10	<0.10	<0.10	0.15	<0.10	<0.10	<0.10	0.10	<0.10	<0.20	0.08	0.13	<0.10	0.10
Cadmium	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Copper	mg/l	0.002	—	0.002	—	0.003	—	0.002	—	<0.001	—	<0.001	—	—	0.001	—	—
Chromium	mg/l	0.00	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	<0.001	<0.001	<0.001	<0.001
Iron	mg/l	0.15	—	0.08	—	<0.02	—	0.13	—	0.13	—	<0.02	—	<0.01	0.03	0.22	0.08
Lead	mg/l	0.001	—	<0.001	—	<0.001	—	0.002	—	<0.001	—	0.008	—	<0.001	<0.001	0.004	0.001
Mercury	mg/l	<0.02	—	<0.02	—	<0.02	—	<0.02	—	<0.02	—	0.45	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	mg/l	0.003	—	<0.005	—	0.002	—	0.003	—	0.007	—	0.012	—	<0.02	0.007	0.033	0.003
Selenium	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vanadium	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Zinc	mg/l	0.005	—	<0.001	—	0.001	—	0.001	—	<0.001	—	0.005	—	<0.001	0.001	<0.001	0.010

Sources: Brown and Caldwell, 1979 and 1980; PGandE, 1979.

WATER TABLE 8c

WATER QUALITY CHARACTERISTICS AT STATION G1.2 1977-1980

Characteristic	Units	3/6/78	4/4/78	5/1/78	6/8/78	7/5/78	8/1/78	9/6/78	10/9/78	11/7/78	12/5/78	1/3/79	2/5/79	5/8/79	8/22/79	11/7/79	2/4/80
Steam Flow	gpm	5,200	2,000	1,000	1,200	1,000	770	810	265	370	211	360	400	1,060	600	680	2,900
Water Temperature	°C	11.0	10.6	13.5	15.0	15.0	16.5	13.1	14.0	11.5	9.0	9.0	6.0	10.5	13.5	12.0	12.0
pH		7.9	7.8	7.3	7.7	7.6	7.4	7.2	7.1	7.2	6.9	7.2	7.4	7.2	7.1	7.5	7.5
Specific Conductance	umho/cm	70	75	73	83	81	86	84	81	72	87	76	74	77	78	84	74
Turbidity	JTU	0.63	1.30	0.45	0.30	0.25	0.40	0.35	0.55	0.30	0.35	0.35	0.35	0.30	0.37	0.40	0.63
Total Dissolved Solids	mg/l	80	76	52	116	64	42	78	62	86	60	72	70	72	71	71	65
Total Suspended Solids	mg/l	1.2	2.8	1.8	1.2	1.6	1.6	0.8	6.0	<0.8	2.8	0.8	<0.8	2.4	2.4	1.8	2
Chemical Oxygen Demand	mg/l	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved Oxygen	mg/l	9.9	10.4	9.5	9.1	9.2	8.8	9.5	9.4	9.6	10.4	13.0	12.3	11.2	9.3	9.6	9.3
Alkalinity	mg/l as CaCO ₃	29	—	—	37	—	—	39	—	—	36	—	—	36	38	39	35
Hardness	mg/l as CaCO ₃	23	—	—	27	—	—	29	—	—	28	—	—	28	27	30	25
Oil and Grease	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammonia, Total	mg/l as N	<0.05	<0.05	0.05	<0.05	0.24	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	<0.01	<0.01	<0.05
Ammonia, Unionized	mg/l as NH ₃	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	—	—	—	—
Nitrate Nitrogen	mg/l as N	<0.01	0.01	0.02	<0.04	<0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite Nitrogen	mg/l as N	<0.002	<0.004	<0.004	<0.004	<0.004	<0.004	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.001	<0.003	<0.001
Sulfate	mg/l	<1.0	<1.3	2.1	1.1	0.9	<1.9	<1.9	2.0	2.2	3.5	<1.0	2.1	1.1	1.0	<2	1.1
Sulfides	mg/l	<0.008	<0.007	<0.005	<0.005	<0.015	<0.007	<0.010	<0.010	<0.020	<0.005	<0.005	<0.020	—	—	—	—
Aluminum	mg/l	0.2	—	<0.1	—	<0.1	—	<0.1	—	<0.1	—	<0.1	—	<0.1	<0.1	0.1	<0.1
Arsenic	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Boron	mg/l	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	<0.10	<0.20	0.02	<0.10	<0.10	<0.10
Cadmium	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	—	—	—	—
Copper	mg/l	0.002	—	0.002	—	0.002	—	0.002	—	0.004	—	<0.001	—	—	0.005	—	—
Chromium	mg/l	0.00	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	<0.01	—	0.033	<0.001	<0.001	<0.001
Iron	mg/l	0.09	—	0.08	—	<0.02	—	0.13	—	0.23	—	0.09	—	0.10	<0.07	0.44	0.06
Lead	mg/l	<0.001	—	<0.001	—	<0.001	—	<0.001	—	<0.001	—	0.008	—	0.004	<0.001	0.005	0.006
Mercury	mg/l	<0.02	—	<0.02	—	<0.02	—	<0.02	—	<0.02	—	0.26	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	mg/l	0.002	—	0.006	—	0.007	—	0.001	—	0.007	—	0.011	—	<0.001	0.009	0.035	0.003
Selenium	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vanadium	mg/l	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Zinc	mg/l	0.002	—	<0.001	—	0.006	—	<0.001	—	0.006	—	0.004	—	0.014	0.007	<0.001	0.009

Sources: Brown and Caldwell, 1979 and 1980; PGandE, 1979.

OXY GEOTHERMAL #1

Characteristics	Unit	3/6/78	4/4/78	5/1/78	6/8/78	7/5/78	8/1/78	9/6/78	10/9/78	11/7/78	12/5/78	1/3/79	2/5/79	5/8/79	8/2/79	11/7/79	2/4/80
Stream Flow	gpm	65,400	15,100	4,430	2,500	2,140	1,040	1,150	1,520	416	500	490	1,480	4,600	1,090	2,800	6,900
Water Temperature	°C	11.5	10.8	14.0	19.0	17.0	19.5	15.6	15.0	12.5	8.0	6.0	6.0	9.9	18.0	12.0	10.5
pH		7.7	7.8	7.8	7.9	7.9	7.5	7.4	7.2	7.3	7.2	7.5	7.8	7.7	7.6	7.9	7.9
Specific Conductance	µMho/cm	129	151	161	146	128	126	118	116	99	136	111	167	177	123	183	148
Turbidity	JTU	3.0	8.90	0.75	0.40	0.25	0.40	0.45	1.30	0.65	2.10	1.20	7.50	7.10	0.75	23.00	1.30
Total Dissolved Solids	mg/l	74	128	96	84	68	60	88	92	82	98	72	111	101	85	126	91
Total Suspended Solids	mg/l	6.2	6.4	1.2	1.6	2.4	<0.8	<0.8	1.6	<0.8	5.2	<0.8	3.2	13.2	1.2	20.0	3.0
Chemical Oxygen Demand	mg/l	<5	<5	6	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Oxygen	mg/l	10.0	10.8	9.6	8.8	9.0	8.5	9.3	9.4	9.9	11.0	12.0	12.4	11.4	9.2	9.9	10.0
Alkalinity	mg/l as CaCO ₃	58			68			55			59			87	59	84	68
Hardness	mg/l as CaCO ₃	54			60			41			48			87	51	83	63
Oil and Grease	mg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ammonia, Total	mg/l as N	0.05	<0.05	<0.05	0.06	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	<0.01	<0.01	<0.05
Ammonia, Unionized	mg/l as NH ₃	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate Nitrogen	mg/l as N	<0.01	0.10	0.01	0.07	<0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.03	<0.01
Nitrite Nitrogen	mg/2 as N	0.003	0.005	0.004	<0.004	0.005	<0.004	0.004	0.006	<0.004	0.004	0.004	<0.004	0.005	<0.001	0.005	<0.001
Sulfate	mg/l	3.2	3.1	4.0	2.3	4.9	3.9	2.2	2.0	2.4	4.0	2.8	5.8	5.9	1.8	5.9	3.4
Sulfides	mg/l	<0.008	<0.007	<0.007	<0.005	<0.025	<0.015	<0.020	<0.010	<0.020	<0.040	<0.030	<0.040				
Aluminum	mg/l	0.1		<0.1		<0.1		<0.1		<0.1		<0.1		1.2	<0.1	2.6	<0.1
Arsenic	mg/l	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001					
Boron	mg/l	0.17	<0.10	<0.10	<0.10	<0.10	0.19	0.14	<0.10	<0.10	0.18	<0.10	<0.20	0.05	<0.10	0.10	<0.10
Cadmium	mg/l	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001					
Copper	mg/l	0.001		0.003		0.003		0.001		0.004		<0.001					
Chromium	mg/l	<0.00		<0.01		0.01		<0.01		0.02		<0.01		0.04	<0.00	0.01	<0.00
Iron	mg/l	0.27		0.12		0.02		0.10		0.33		0.09		0.80	0.04	1.90	0.24
Lead	mg/l	0.037	0.011	<0.001		<0.001		0.003		<0.001		0.003		0.010	0.001	0.008	<0.001
Mercury	mg/l	0.04		<0.02		<0.02		<0.02		<0.02		0.48	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	mg/l	0.003		0.003		0.003		0.001		0.014		0.015		0.003	0.028	0.046	0.002
Selenium	mg/l																
Vanadium	mg/l																
Zinc	mg/l	0.004		0.068	0.003	<0.001		<0.001		<0.001		0.001		0.011	0.031	0.003	0.013

TABLE 8d: WATER-Water Quality Characteristics at Station A 1.8, 1977-1980

OXY GEOTHERMAL #1

LEGEND

- CREEK
- ▲ SINGLE EVENT WATER QUALITY SAMPLING STATION
- SEMI ANNUAL WATER QUALITY SAMPLING STATION
- TWO-YEAR WATER QUALITY AND FLOW MONITORING STATION
- BC WATER QUALITY AND FLOW MONITORING STATION
- △ OCCIDENTAL WATER QUALITY MONITORING STATION

SCALE IN FEET

Source: Brown & Caldwell (1981)

FIGURE 3: WATER-Surface Water Courses and Location of Sampling Stations

OXY GEOTHERMAL # 1

Parameter	Station A 1.8	Station A 2.7	Station A 2.8	Station G 0.3	Station G 1.2
	Samples/exceeded MCL	Samples/exceeded MCL	Samples/exceeded MCL	Samples/exceeded MCL ^a	Samples/exceeded MCL
Primary standards					
Arsenic	6/	6/	6/	6/	6/
Cadmium	6/	6/	6/	6/	6/
Chromium	10/	10/	10/	10/	10/
Lead	11/	10/	10/	10/	10/
Mercury	11/	11/	11/	11/	11/
Nitrate	16/	16/	16/	16/	16/
Turbidity	16/9	16/8	16/3	16/3	16/1
Secondary standards					
Copper	7/	7/	7/	7/	7/
Iron	10/3	10/1	10/	10/	10/1
Zinc	11/	10/	10/	10/	10/
Total dissolved solids	16/	16/	16/	10/	10/
Specific conductance	16/	16/	16/	16/	16/
Sulfate	16/	16/	16/	16/	16/

^aSamples = total number of samples analyzed for parameter during two-year survey. Exceeded MCL = total number of samples analyzed during two-year survey which yielded values that exceeded maximum contaminant level (MCL) for parameter. A number is not listed if no sample exceeded MCL.

Source: PGandE - Aminoil two-year water quality monitoring program of the Anderson Creek drainage.

Note: See Figure 3-1 for location of sampling stations.

TABLE 9: WATER-Anderson Creek Water Quality Monitoring Results to Selected Water Quality Standards

the MCLs for total dissolved solids, specific conductance, or sulfate. However, the reader should note that all the foregoing measures of water quality increased in the downstream direction until the better quality water from Gunning Creek diluted the flow in Anderson Creek at Station A-1.8.

Note the same pattern for turbidity, which increased proceeding downstream on both Gunning and Anderson creeks and decreased at Station A-1.8 on Anderson Creek below its confluence with Gunning Creek. All of the maximum turbidity values exceeded the monthly average MCL of 1.0 turbidity unit for surface water sources not exposed to significant sewage hazards or significant recreational use. CEC staff points out, however, that the average turbidities at stations G-1.2 (0.45 mg/l) and G-0.3 (0.67 mg/l) on Gunning Creek were less than the MCL.

LOCAL AND REGIONAL GROUNDWATER AQUIFERS

Regional

No regional groundwater aquifers of significant yield have been reported in the rock formations of the Mayacmas Mountains in The Geysers area. The area is principally underlain by fractured sedimentary rock belonging to the Franciscan formation of the Jurassic-Cretaceous age. Franciscan rocks are generally classified as nonwater bearing except along fracture zones, which may contain minor amounts of groundwater. Small quantities of groundwater may also be present in unconsolidated surficial materials, especially in landslide deposits.¹⁹

Significant groundwater basins exist in the alluvium of the valleys at the base of either side of the Mayacmas mountain range. United States Geological Survey Water-Supply Papers²⁰ and State of California Department of Water Resources^{21,22} bulletins contains well locations, records of water levels, and groundwater contour maps for these valley areas.

Local

Test borings and subsurface exploration at the Oxy project site indicate that no significant groundwater aquifers exist within 75 feet of ground surface.²³ Occidental's investigation of the leasehold also revealed no significant groundwater resources in the project site vicinity. However, free water was encountered in all test borings at the plant site.²⁴ Energy Commission staff observed standing water in drill holes on Pad "D" during June of 1981.

Springs which feed Anderson Creek and Gunning Creek from the northeast occur generally at the base of the Cobb Mountain Rhyolite, with their recharge area lying at higher elevations on Cobb Mountain. Activities at the proposed site should not affect or be affected by groundwater, because the groundwater rises at higher elevations and is separated from the proposed power plant site by a number of drainages. Recharge characteristics and topography of the proposed plant site indicate that groundwater, other than perched or trapped water, lies at a depth of several hundred feet.

WATER QUALITY

SETTING

Occidental conducted a review of historical data which described chemical and physical characteristics of the waters in the Anderson and Gunning creeks drainages. The data were assembled to document conditions existing prior to the Occidental leasehold development. Oxy evaluated the available data in terms of the closeness of sampling locations to the Occidental site, the number of highflow-lowflow cycles sampled, the water quality indicators investigated, and the dates the work was performed.

HISTORICAL DATA

In 1981, Brown and Caldwell, Inc.,²⁵ prepared for Occidental the most complete site-specific and recent data for the Anderson and Gunning creeks watersheds. The study included the collection of historical water quality information plus limited additional water quality sampling and analysis. Brown and Caldwell incorporated, in their most recent report, the results of a two-year baseline monitoring study which they conducted for PGandE and Aminoil, Inc. During the earlier study (1978-80) they established 15 sampling sites throughout the upper Putah Creek drainage at which streamflow and water quality were monitored. They gathered water quality samples monthly during the first year and quarterly during the second year of the study. During the current investigation, Brown and Caldwell took spot samples of Gunning and Anderson Creek for general water quality, radiological content, and suspended solids during high flow periods (see Water Tables 7 and 10).

Of the 15 stations in the Putah Creek drainage (see Water Figure 3), CEC staff considered only 5 on Anderson and Gunning creeks reflective of disturbance on the Oxy leasehold. Three of the stations were located within one mile of the Occidental leasehold and would most directly reflect adverse impacts of site development. The nearest station was on Gunning Creek below the Ford Flat Road, 1.2 stream miles (G1.2) above its confluence with Anderson Creek. The other two stations were on Anderson Creek, 2.7 and 2.8 stream miles (A2.7 and A2.8) above the confluence of Anderson and Putah creeks. Both were near the Anderson Creek/ Twin Creeks bridge on Socrates Mine Road. One was placed above and the other below the confluence of Anderson Creek with an unnamed tributary, which flows along the Socrates Mine Road and drains the site of PGandE Unit 13.

Of the remaining two stations, one was located on Gunning Creek above its confluence with Anderson Creek (G0.3). The other (A1.8) was situated on Anderson Creek below its confluence with Gunning Creek.

Water Tables 10 through 15 present the results of three years of sampling at these five stations. Table 11 summarizes water quality data from single-event sampling during 1975 and 1976. These data were taken from the 1975 Environmental Impact Report (EIR) for the Castle Rock Springs geothermal steam area and PGandE's Geysers Unit 16 site-specific studies.^{26,27} As Water Tables 11 and 12 indicate, drinking water quality standards were exceeded only twice, once for mercury and once for turbidity. Both samples were collected from Anderson Creek near the community of Anderson Springs.

WATER TABLE 10
RESULTS OF SPECIAL SAMPLING OF ANDERSON
AND GUNNING CREEKS

Parameter ^a	Anderson Creek	Gunning Creek	Parameter ^a	Anderson Creek	Gunning Creek
Arsenic	<0.0005	<0.0005	2, 4, 5-TP Silvex	^b	^b
Barium	<0.1	<0.1	Bacteriological	>16 ^c	>16 ^c
Cadmium	<0.001	<0.001	Turbidity	0.25	0.35
Chromium	<0.01	<0.01	Color, units	8	5
Fluoride	0.13	0.11	Copper	<0.001	<0.002
Lead	0.001	0.001			
Mercury	<0.0001	<0.0001	Iron	<0.01	0.04
Nitrate	<0.05	<0.05	Manganese	<0.01	<0.01
Selenium	<0.0005	<0.0005	Odor-threshold, units	2	1
Silver	<0.001	<0.001	Foaming agents, (MBAS)	<0.025	<0.025
Endrin	^b	^b	Zinc	<0.01	<0.01
Lindane	^b	^b	Total dissolved solids	116	83
			Specific conductance, umhos/cm	125	77
Methoxychlor	^b	^b	Chloride	1.0	1.1
Toxaphene	^b	^b	Sulfate	4.2	<1.0
2, 4-D	^b	^b			

^aIn mg/l unless otherwise noted.

^bNone detected. Detection limits are as follows: endrin, 0.0001 mg/l; lindane, 0.00005 mg/l; methoxychlor, 0.0002 mg/l; toxaphene, 0.001 mg/l; 2, 4-D, 0.0005 mg/l; silvex, 0.0001 mg/l.

^cColiform counts exceeded 16/100 ml as determined by the multiple-tube fermentation technique.

Source: Samples taken by BC personnel on November 20, 1980, and analyzed by Environmental Sciences Division of BC.

WATER TABLE 11
SUMMARY OF HISTORICAL WATER QUALITY DATA
RESULTING FROM SINGLE-EVENT SAMPLING

Parameter ^a	Gunning Creek	Anderson Creek		
	8-12-75 ^b	8-12-75 ^c	A 0.3 10-18-76	A 1.6 10-18-76
Primary standards	-	-	-	-
Arsenic	-	-	-	-
Barium	-	-	-	-
Cadmium	-	-	-	-
Fluoride	0.08	<0.02	-	-
Lead	-	-	-	-
Mercury	<0.001	0.0022 ^h	<0.001	<0.001
Nitrate	<0.01	0.01	-	-
Turbidity, JTU	0.3	0.4	0.35	63 ^d
Secondary standards				
Copper	-	-	-	-
Iron	0.03	0.03	-	-
Manganese	<0.05	<0.05	-	-
Zinc	-	-	-	-
Total dissolved solids	63	84	230	180
Specific conductance, umhos/cm	75	120	-	-
Chloride	2.5	3.5	-	-
Sulfate	0.5	3.3	3.2	0.36

^aUnits in mg/l unless otherwise noted.

^bStation location unknown.

^cStation located just before confluence with Putah Creek.

^dValue exceeds maximum contaminant level.

Source: 1975 data - EIR for Castle Rock Springs Geothermal Steam Area,
prepared for Burmah Oil and Gas Company, August 1975.

1976 data - PGandE's Geysers Unit 16 Site Specific Studies,
Preliminary Investigations of Water Quality Characteristics,
April 1977.

Note: See Figure for location of sampling stations.

WATER TABLE 12
CALIFORNIA DRINKING WATER STANDARDS

Parameter ^a	Maximum Containment Level	Parameter ^a	Maximum Contaminant Level
Primary standards		Secondary standards	
Inorganic chemicals		Consumer acceptance limits	
Arsenic	0.05	Color, units	15
Barium	1	Copper	1.0
Cadmium	0.010	Corrosivity	^e
Chromium	0.05	Iron	0.3
Fluoride, ^b if added	0.8 - 1.7	Manganese	0.05
if naturally occurring	1.4 - 2.4	Odor - threshold, units	3
Lead	0.05	Foaming agents (MBAS)	0.5
Mercury	0.002	Turbidity, units ^f	5
Nitrate, as NO ₃	45	Zinc	5.0
Selenium	0.01	Mineralization	
Silver	0.05	Total dissolved solids	
Organic chemicals		Recommended	500
Endrin	0.002	Upper	1,000
Lindane	0.004	Short-term	1,500
Methoxychlor	0.1		
Toxaphene	0.005	Specific conductance,	
2, 4-D	0.1	micromhcs/cm	
2, 4, 5-TP Silvex	0.01	Recommended	900
Radioactivity		Upper	1,600
Radium-226 + radium-228, pCi/l	5	Short-term	2,200
Gross Alpha particle activity, pCi/l	15	Chloride	
Tritium, pCi/l	20,000	Recommended	250
Strontium-90, pCi/l	8	Upper	500
Gross Beta particle activity, pCi/l	50	Short-term	600
Bacteriological ^c	-	Sulfate	
Turbidity, units ^d	1	Recommended	250
		Upper	500
		Short-term	600

^aIn milligrams per liter (mg/l) unless otherwise indicated.

^bVaries with ambient temperature.

^cMaximum contaminant level depends upon analytical technique.

^dSurface water source not exposed to significant sewage hazards or significant recreational use; no consecutive two-day average can exceed 5 units.

^eRelatively low.

^fApplies to water in the distribution system.

WATER TABLE 13
SUMMARY OF HISTORICAL WATER QUALITY DATA
RESULTING FROM SEMIANNUAL SAMPLING

Parameter ^a	Anderson Creek ^b			Unnamed Tributary ^c			Gunning Creek ^d		
	2/5/76	8/25/76	2/9/77	2/5/76	8/25/76	2/9/77	2/5/76	8/25/76	2/9/77
Primary standards									
Fluoride	0.16	0.24	0.24	0.16	0.22	0.12	0.07	0.14	0.12
Mercury	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	0.0015	<0.001
Nitrate	<.44	<.44	<.44	<.44	<.44	<.75	<.44	<.44	<.44
Turbidity, JTU	<0.5	<0.5	5.8 ^e	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Secondary standards									
Iron	<0.2	<0.2	0.75 ^e	<.02	<.02	.45 ^e	<.02	<.02	<0.1
Manganese	<0.05	<0.06 ^e	<0.06	<.05	<.06 ^e	.07 ^e	<.05	<.05 ^e	<.06 ^e
Total dissolved solids	125	130	160	200	280	140	80	110	32
Specific conductance, umhos/cm	180	150	220	375	400	270	80	70	73
Chloride	2.5	1.6	3.2	4.7	4.3	2.6	1.3	0.9	1.1
Sulfate	4	6	11	6.0	18	97	<0.5	<1.0	2.0

^aUnits in milligrams per liter.

^bAnderson Creek above Putah Creek.

^cUnnamed tributary of Anderson Creek above Station A 2.7.

^dGunning Creek below Socrates Mine Road.

^eValue exceeds maximum contaminant level.

Source: PGandE - Aminoil two-year water quality monitoring program of the Anderson Creek drainage.

Note: See Figure 1 for location of sampling stations.

OXY GEOTHERMAL #1

Parameter ^a	Station A 1.8		Station A 2.7		Station A 2.8		Station G 0.3		Station G 1.2	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Primary standards										
Arsenic	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Cadmium	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Chromium	0.00	0.043	0.00	0.038	0.00	0.01	0.00	0.047	0.00	0.033
Lead	<0.001	0.037	<0.001	0.01	<0.001	0.008	<0.001	0.006	<0.001	0.008
Mercury	<0.00002	0.00048	<0.00002	0.00003	<0.00002	0.00045	<0.00002	0.00065	<0.00002	0.00026
Nitrate	<0.01	0.10 ^b	<0.01	0.08 ^b	<0.01	0.06 ^b	<0.01	0.05 ^b	<0.01	0.04 ^b
Turbidity, NTU	0.25	23 ^b	0.20	100 ^b	0.20	2.70 ^b	0.20	2.40 ^{b,c}	0.25	1.30 ^{b,c}
Secondary standards										
Copper	<0.001	0.006	<0.001	0.005	<0.001	0.003	<0.001	0.004	<0.001	0.004
Iron	0.02	1.9 ^d	<0.01	0.66 ^d	<0.02	0.50 ^d	<0.01	0.54 ^d	<0.02	0.44 ^d
Zinc	<0.001	0.068	<0.001	0.026	<0.001	0.005	<0.001	0.045	<0.001	0.014
Total dissolved solids	60	128	73	164	72	152	44	128	42	116
Sulfate	1.8	5.9	2.8	8.6	2.9	7.0	<1.0	3.1	0.9	3.5

^aUnits in mg/l unless otherwise noted.

^bValue exceeds monthly average MCL of 0.5 turbidity units.

^cAverage turbidities (NTU) by station are as follows: G 0.3 - 0.67; G 1.2 - 0.45.

^dValue exceeds MCL.

TABLE 14: WATER-Summary of Anderson Creek Drainage Basin Water Quality Monitoring Results (1978-1980)

WATER TABLE 15
WATER QUALITY IN THE ANDERSON SPRINGS WATER COMPANY
DISTRIBUTION SYSTEM

Parameter ^a	Anderson Creek Source ^b	Gunning Creek Source ^c
Primary standards		
Fluoride	0.1	0.1
Nitrate	1.5	0.4
Secondary standards		
Fluoride	0.01	0.01
Manganese	0.01	0.01
Turbidity, units	0.35	0.25
Total dissolved solids	228	111
Chloride	7.0	4.0
Sulfate	6.7	4.5

^aUnits in mg/l unless otherwise noted.

^bSample point located at Wyrick hose bibb below tank 3. Sample taken April 19, 1979.

^cSample point located at Szymanski's hose bibb. Sample taken May 8, 1979.

Source: State Department of Health Services, Sanitary Engineering Section.

Semiannual water quality sampling was conducted between February 1976 and February 1977 and was included in the Draft EIR for Aminoil's East Ford Flat Road Geothermal Project.²⁸ Selected data from this monitoring effort appear in Water Table 13; the table identifies values which exceed MCLs (maximum contaminant level). This data shows that the water quality in Anderson Creek is generally good except during winter periods of high flow when turbidity, iron, and manganese exceed standards for drinking water. The quality of Gunning Creek water was excellent throughout, with only a slight (0.01 mg/l) overage in manganese.

Between March 1978 and February 1980 Brown and Caldwell,²⁹ on behalf of PGandE and Aminoil, conducted a two-year water quality monitoring program of the upper Putah Creek watershed. This program consisted of monthly sampling during the first year and quarterly sampling the second year at stations which included those shown on Water Figure 3. This figure identifies the stations by the first letter or letters of the stream on which they are located and the projected horizontal distance in miles from the mouth of that stream. Data collected during the two-year study provided interesting insight into the relative water quality of streams in the Anderson Creek watershed. Note that the characteristics of Anderson Creek change as it flows towards its mouth due to inflow from several tributaries.

Streamflow from the intermittent tributary, which flows from PGandE Unit 13 along the Socrates Mine Road, contributed dissolved but particularly suspended solids during runoff periods (Station A2.7). This caused increased specific conductance, higher turbidity, and a slight increase in alkalinity and hardness (see Water Table 8). Further downstream at Station A1.8 the high quality inflow from Gunning Creek (G1.2) caused a noticeable drop in specific conductance, total dissolved solids, sulfates, alkalinity, and hardness in Anderson Creek.

One can use portions of the data collected during the two-year monitoring program to determine the suitability of the various water sources for domestic supply. In Water Table 14, the minimum and maximum values for selected constituents appear for the five locations on Anderson and Gunning creeks, which would most likely reflect upstream activities on the Occidental leasehold. These data serve to illustrate the range of values found during the monitoring program. Water Table 9 summarizes the total number of samples analyzed for selected contaminants versus the number of those samples which exceeded the corresponding MCL. The generally good water quality is apparent from the available data. For the selected stations, the MCL for turbidity of one unit was exceeded in a large number of samples due to runoff during the rainy season. The secondary MCL for iron was exceeded in 5 out of 50 samples taken in the Anderson Creek watershed.

The California Department of Health Services monitored the water quality of the Anderson Springs Water Company distribution system in April and May of 1979 for some of the parameters required by California Domestic Water Quality Monitoring Regulations, Title 22 of the California Administrative Code. Water Table 15 presents selected data from this survey. None of the values exceeded the applicable MCLs.

On April 22, 1980, Edwin E. Crawford of the Central Valley Regional Water Quality Control Board³⁰ conducted a sanitary survey of Anderson Creek. Fecal

coliform levels ranged from 2 to 14 organisms per 100 milliliters (ml). Although he found no visible evidence of raw sewage or septic tank effluent, Mr. Crawford concluded that the fecal coliform levels were evidence of sewage contribution from homes in the area. According to Standard Methods for the Examination of Water and Wastewater, the fecal coliform test, if positive, identifies the presence of coliforms from the intestines of warm-blooded animals, not necessarily humans.

Special Water Quality Monitoring

In order to assess local water quality adequately in relation to Title 22 water quality standards, Brown and Caldwell personnel gathered two samples from Anderson and Gunning creeks at the locations shown on Water Figure 3 and analyzed these for the required water quality constituents. These data appear in Water Table 10. Comparing the data to the drinking water standards in Water Table 12, it is evident that the water quality at both stations is excellent, with most measured values well below the MCLs listed for treated waters. Coliform bacteria counts, which exceeded 16 per 100 ml, were the exception. Standard disinfection kills coliform organisms. Therefore, coliform counts do not indicate a significant water quality problem for raw water.

In February of 1981, Brown and Caldwell collected samples at the same stations for radiological analyses. The results were as follows:

<u>Constituent</u>	<u>Gunning Creek</u>	<u>Anderson Creek</u>
Gross alpha	0.04 + 0.81	0.4 + 0.7
Gross beta	1.6 + 2.2	0.1 + 5.6

Note: All data in picoCuries per liter.

These concentrations are well below the MCLs in Table 12 and are at or below typical background levels.

To determine the impacts of storm runoff on the upper reaches of Gunning Creek, an Occidental Geothermal employee gathered additional grab samples for suspended solids analysis at the Ford Flat Road crossing and from an intermittent tributary to Gunning Creek about 100 meters north of the Aminoil PDC-1 drill pad site. The employee collected approximately 40 samples between December 12, 1980, and March 1, 1981, during or immediately following rainstorms. Water Table 7 summarizes the resulting data and also presents rainfall data for the same dates taken at PGandE power plant 13, located about 2,300 meters south of the sampling stations.

Suspended solids data indicate little, if any, extraneous disturbance of the Gunning Creek watershed. Pristine, undisturbed watersheds have yielded more than the seven or eight milligrams per liter transported by Gunning Creek and its tributary.³¹ Suspended solid concentrations less than 20 mg/l could be caused by such internal events as swimmers or a deer crossing the stream. Storm runoff from watersheds disturbed by logging or construction activities would be expected to result in suspended solid concentrations greater than 20 mg/l. The rainfall events which produced 20 mg/l were neither the first heavy

rainfall of the season nor the heaviest that could be expected. In contrast, the first major rainstorm of the 1980-81 record period dropped more than 13 inches at Power Plant 13 in 48 hours. Much higher (i.e., > 20 mg/l) suspended solids concentrations should be expected from storms dropping 13 inches in 48 hours.

EVALUATION OF WATER QUALITY

Review of historical water quality data indicates that surface water courses within the Anderson Creek drainage are generally of high quality but do exhibit some seasonal fluctuations. The data for the Anderson and Gunning creeks watersheds which supply recreational and/or potable water for Anderson Springs are discussed individually, followed by an overall evaluation.

Gunning Creek

The waters of Gunning Creek are generally of higher quality than water from other sources in the study area. Samplings by Brown and Caldwell, in 1976 and 1977 did show the MCL for manganese was exceeded slightly on two occasions. Tables 9 and 14 also show two cases when the MCL for iron was exceeded and four cases where the turbidity MCL was exceeded. The high turbidity value was only 2.4 units (0.4 of a unit over the MCL), however, and the iron levels were only slightly above the MCL. Gunning Creek water quality was marginally better for samples taken at locations further upstream. The data in Water Table 10 confirms the generally high quality of water from upper Gunning Creek and indicates that conditions in November 1980 were not substantially different from those during previous sampling.

Anderson Creek

Water samples from Anderson Creek generally decrease in quality the closer they get to Anderson Creek's confluence with Putah Creek. The change is probably most dependent on the water quality of tributary streams. Data for 1975 and 1976 show some high turbidity and manganese values. Water Tables 9 and 14 show a number of high turbidity and iron values, especially in the reach below Socrates Mine Road (Stations A0.5, A1.3, A1.8, and A2.7). Sampling by the Central Valley Regional Water Quality Control Board also showed increases in fecal coliform in Anderson Creek within the community of Anderson Springs. The water quality of Anderson Creek appears to be especially susceptible to degradation due to the removal of native vegetation and the attendant soil erosion. Most of the recent vegetation removal and soil erosion comes as a result of road and geothermal resources development in the Anderson Creek watershed, although mining, timber removal, and recreational activity have also contributed to soil and vegetation loss as observed by CEC staff and indicated by U.S. Geological Survey Quadrangle sheets.

WATER USE

People use water from Anderson and Gunning creeks for domestic consumption and recreation, and to a lesser extent for industrial and agricultural purposes. Gunning Creek supplies 70 percent of the potable water for the approximate 700 residents of the Anderson Springs community.³² Summer consumption has been

restricted to household use because of reduced streamflow. High suspended sediment loads in Gunning Creek during storms forces closure of the system, at which time the residents depend on numerous springs in the area for their domestic supply. People use the water in Anderson Creek primarily for recreation; however, three residences depend on it for their domestic supply.

IMPACTS

POWER PLANT SITE

Surface Water

Removal of vegetation and disturbance of the soils on the 16.7 acre plant site will increase the potential for erosion and sediment deposition in an intermittent tributary of Anderson Creek. Depending on weather conditions and the mitigation measures proposed by Oxy, erosion should decrease with time as cut and fill slopes stabilize. CEC staff used regional flood frequency equations developed by Waanen and Crippen³³ to estimate peak runoff for a 1:100 frequency storm from the 16.7 acre plant site to be 27 cubic feet per second.

Assuming a 6-hour storm and a 15-minute time of concentration, the surface flow from the plant site would fill the sediment basin to overflowing in approximately 2 hours.

The potential for high erosion rates will exist until Oxy revegetates all disturbed areas and stabilizes the soil. During power plant operation, drainage from disturbed areas will collect in lined ditches and flow to the sedimentation pond via a network of surface and underground drains (see Water Figure 4). According to Occidental, the sediment pond has a capacity to store 10,780 cubic feet of sediment (approximately 641 tons). Occidental personnel will remove the accumulated sediment annually. Oxy has not stated how they will dispose of the accumulated sediment.

With exception of storm runoff Oxy intends to inject all water-borne wastes into the geothermal reservoir. During heavy storms, when the capacity of the injection line is exceeded, storm water will discharge directly into the Anderson Creek tributary. This water, collected from roof drains and parking areas, will have qualities more similar to urban and industrial areas than runoff from natural areas.

The Geysers KGRA has a long history of pollution incidents attributed to geothermal development.³⁴ Forty out of 68 incidents recorded since 1965 were directly attributable to power plants. The preponderance (29) involved the discharge of steam condensate into local streams. The causes of condensate discharge in order of frequency were pipeline failures (10), mechanical breakdown of valves and control devices (10), and human error (3). The remaining incidents involved improper waste handling and disposal (3), settling pond overflow (2), landslides attributable to poor foundation conditions (1), and a spill caused by a vehicle accident (1). The combination of mechanical failure and human error indicates the continued potential for adverse impact to local water resources during the construction and operation of the Occidental Geothermal Power Plant No. 1.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 4: WATER-Cut and Fill Drainage Plan

Groundwater

The Oxy AFC indicates, and CEC staff concurs that accelerated erosion due to construction activities could have significant effects on the numerous perennial springs and seeps in Anderson Creek and on the unnamed tributary below the power plant site. These water sources provide valuable drinking water for wildlife and habitat for aquatic biota. Excessive siltation in the creek could eliminate the amphibian population in the upper reaches of Anderson Creek.

TRANSMISSION LINE

The preferred and alternative transmission alignments (see Water Figure 6) will disturb approximately 13 acres inclusive of necessary access roads. Most of the disturbance will be within the Big Sulphur Creek watershed, which is already impacted by the construction of 13 power plants and development of approximately 40 well pads. Although the amount of vegetation removed and soil disturbed will be small, it will add incrementally to erosion and surface water degradation in the watershed.

MITIGATION MEASURES

POWER PLANT SITE

Occidental's overall mitigation plan³⁵ will consist of (1) erosion, sediment and spill control; (2) revegetation of cut and fill slopes of the plant site and plant access road; and (3) habitat enhancement programs.

Erosion control measures, discussed in the soils section, will be implemented by Occidental to reduce sediment loads in storm runoff from cut and fill slopes. A comprehensive storm drainage system (See Water Figures 4 and 5) will be provided to accommodate 100-year storm precipitation. The facilities will include catch basins, culverts, ditches, berms, catch dams, riprap, energy dissipators, and a sedimentation pond.

Drainage from approximately 36 acres will be intercepted by the sedimentation pond. This estimate includes both developed and undisturbed areas. The amount of sediment eroded from the 16 acre plant site has been variously estimated from 55 to 200 tons per acre during construction. As a consequence, from 880 to 3,200 tons of sediment could be washed into the pond during earth moving activities. This assumes that there is no ground cover and the site receives intense rainfall. Assuming a loss of 4.2 tons/acre after vegetation is established, the sediment yield from the total 36 acres would be reduced to 150 tons per year. The pond is sized to collect 480 tons while maintaining 5 feet of freeboard. The sediment will collect in the pond, and Oxy staff will quantify and remove it annually for the first three years of operation.

To prevent accidental spills and contaminated storm water from entering Anderson Creek, Oxy will construct a 0.5 foot high berm around the entire site, which will drain to catch basins. Oxy will pump storm water which falls inside the paved bermed area to the cooling tower basin.

The purpose of the berm is to contain spills from the cooling tower basins. Available storage within the berm is approximately 107,000 cubic feet.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 5: WATER-Site Drainage Plan

OXY GEOTHERMAL # 1

Source: Oxy #1 AFC

LEGEND

- OXY SITE
- ✕ PROPOSED OXY TOWER SITES
- ▲ PG&E UNITS
- △ EXISTING PG&E TOWERS
- SMUDGE #1
- PROPOSED SMUD TOWERS
- EXISTING ROADS AND TRAILS
- - - PROPOSED TRANSMISSION ACCESS ROADS

FIGURE 6: WATER-Proposed and Alternate Transmission Route

According to Oxy, this storage volume exceeds any potential spill anticipated from the cooling tower basins or circulating water system, assuming a four foot drawdown in the basins before the circulating water pumps trip.

Oxy will pave and curb other areas which contain chemicals, such as chemical storage, chemical processing, transformers, and fuel oil storage. The power plant design will direct spills and storm water from these areas to the plant treatment system, treat it for oil removal, and pump it to the cooling tower basins for evaporation or reinjection.

Annunciator systems on the cooling tower basin, Stretford unit, lube oil system, and chemical storage tanks will warn plant operators of abnormal operation.

Drift eliminators on the cooling tower will reduce drift to 0.001 percent of the circulating water flow.

Licensed carriers will haul chemicals and wastes in containers which conform to applicable sections of the Code of Federal Regulations (CFR), Title 49.

In the event of an uncontained spill or leak causing pollution of local waters, Occidental will retain a qualified spill cleanup contractor as needed to assist in the cleanup.

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BIOLOGICAL RESOURCES

SETTING

The Oxy AFC describes the Occidental Geothermal leasehold biological setting (Occidental Geothermal, Inc., 1981). The following paragraphs summarize the information contained in this document with additional information incorporated where necessary. CEC staff verified the information through examination of the site, review of available pertinent information, and discussions with appropriate individuals and agencies.

VEGETATION

The project site consists of the 11 identifiable vegetation habitat types which generally follow those described by Cheatham and Haller (1975). Vegetation types are listed along with approximate area of coverage in Biology Table 1 and are described below. The distribution of vegetation was mapped based on recent aerial photography and is presented in Biology Figure 1. Some of these plant communities (e.g., serpentine chaparral, riparian woodland, and rock outcrop vegetation) are highly distinct with relatively well-established boundaries which can be closely correlated to soil and/or moisture conditions. Others (e.g., mixed chaparral, scrub oak chaparral, and yellow pine forests) are more successional in nature and tend to be less distinct, often integrating in a continuum.

The vegetation on the site has been strongly influenced by the area's history. A large wildfire burned through the site approximately 20 years ago, killing many large conifers and establishing conditions which have encouraged formation of the large chaparral areas present today. Many large "snags" remain from this prefire forest and now serve as important wildlife habitat.

BIOLOGY TABLE 1

VEGETATION TYPES ON THE OXY LEASEHOLD

<u>Plant Community</u>	<u>Approximate Area of Coverage</u>	
	<u>Acres</u>	<u>Hectares</u>
Mixed Californian Chaparral	192.8	77.9
Chamise Chaparral	30.5	12.3
Serpentine Chaparral	9.0	3.6
Ponderosa Pine Forest	161.6	65.3
Mixed Evergreen Forest	26.7	10.8
Canyon Live Oak Forest	24.1	9.7
Knobcone Pine Forest	24.3	9.8
Riparian Strip	3.9	1.6
Annual Grassland	5.7	2.3
Rock Outcrops	15.6	6.3
Seeps and Springs	--	--
Disturbed Areas	25.8	10.4

OXY GEOTHERMAL #1

VEGETATION TYPES

MXC — Mixed Californian Chaparral	KPF — Knobcone Pine Forest
CHC — Chamise Chaparral	RS — Riparian Strip
SCH — Serpentine Chaparral	ANG — Annual Grassland
PPF — Ponderosa Pine Forest	RO — Rock Out Crops
MEF — Mixed Evergreen Forest	D — Disturbed Areas
CLO — Canyon Live Oak Forest	OW — Northern Oak Woodland

FIGURE 1: BIOLOGY—Occidental Biology

The leasehold contains a complex arrangement of plant communities, with chaparral and yellow pine forest communities covering well over half of the leasehold area. Cheatham and Haller (1975) divide the chaparral vegetation on the leasehold into several distinct plant communities, including mixed Californian chaparral, chamise chaparral, and serpentine chaparral.

Mixed Californian chaparral (scrub oak chaparral and manzanita chaparral) (Hanes, 1977) covers approximately 192.8 acres, constituting the most common vegetation type on the project site. Mixed chaparral is characterized by tall (2 - 4 m) shrubs, forming nearly impenetrable vegetation with heavy litter accumulation (Cheatham and Haller, 1975). Manzanita, scrub oak, and buck brush are typically dominant, but species composition does vary from one area to another. Other shrubs, including toyon, coffeberry, silk tassel bush, California bay, and chaparral pea can be locally abundant.

Chamise chaparral is characterized by lower (1 - 3 m) shrubs which are more sparsely spaced, often with bare soil between shrubs and very little litter accumulation. Chamise chaparral typically occurs on dry rocky slopes with southern exposures. Species diversity is very low, with chamise comprising about 90 percent of the species present. Randomly scattered buck brush and manzanita are also occasionally present.

Serpentine chaparral also exists on the leasehold and is a locally important vegetation type which supports numerous endemic species. These include jepson's ceanothus, leather oak, and stanford's manzanita, which are often codominant. Occasionally there are large patches of bare soil between the shrubs. Herbaceous species are often present and are well represented by species restricted to this soil condition. Several of the rare plants in The Geysers KGRA are serpentine endemics. Disturbance of these sites must be preceded by careful study for sensitive species to avoid inadvertent loss of these species.

Ponderosa pine forest covers approximately 161.6 acres and makes up the second most common vegetation type in the Occidental Leasehold. Tall ponderosa pines and black oak with a well-developed shrub understory comprised of dear brush, manzanita, bracken fern, iris, and occasionally squaw carpet generally characterize the ponderosa pine forest on the site. Portions of this plant community have been affected by wildfire and logging which occurred approximately 20 years ago on the southeast side of Cobb Mountain. These areas are currently in an earlier stage characterized by lower, denser individuals.

Mixed evergreen forest exists primarily on the moist slopes within the leasehold. Dominant species include douglas fir, madrone, California bay, and canyon live oak. These form a dense canopy under which few other species grow. However, a few scattered shrubs (including poison oak) and herbaceous species do occur.

Another forest type on the leasehold is the canyon live oak forest. This vegetation type is characterized by the presence of canyon live oak, interior live oak, black oak, and California bay. It typically forms a forest of tall trees (up to 50.8 cm in diameter) on north-facing slopes and in canyon or dense chaparral-like cover on south-facing slopes.

Knobcone pine forest is also found on the leasehold. These areas are characterized by an upper canopy up to 10 m high comprised almost solely of knobcone pine, with a dense shrub understory of manzanita and a few other shrubs. Vogel et al. (1977) provides an excellent composition and ecology review of this plant community.

Riparian vegetation occurs as a narrow strip lining the banks of Anderson and Gunning creeks. Woody species include white alder, willow, spice bush, and big-leaf maple. Sedges and chainfern are among the herbaceous species present.

A small area of annual grassland exists on the east side of the leasehold. Species present include a variety of introduced annual grasses with a few native wildflowers.

Other important plant habitats include rock outcrops and seeps and springs. Rock outcrops are common on the Occidental leasehold and provide habitat for a number of perennial herbs. Seeps and springs are important for the herbaceous species they support and as watering sources for wildlife. Small intermittent springs are located in many locations on the leasehold. One larger perennial spring is located below the power plant site and is important in that it supports a number of uncommon species.

Rare and Endangered Plants

The Geysers region is noted for its complex arrangement of vegetation, soils, and topography. As a result, this region also supports a relatively large number of endemic plant species which are rare or endangered. Biology Table 2 lists the status of rare plants which are known or suspected to occur in The Geysers KGRA (Smith et al., 1980). This table separates species which have been identified as rare and endangered (CNPS List 2) from those which are recognized as rare but not endangered (CNPS List 3). Rare and endangered species are those which require a high level of protection in most instances. Species which are rare but not endangered may be indicators of special biological areas and may also require preservation under specific circumstances.

At present no rare plants are known to occur on the project leasehold. However, because rare plant studies have not been completed at this time, Staff does not view lack of known rare plants present on the leasehold as conclusive.

WILDLIFE

The Occidental leasehold provides important habitat for wildlife species. The combination of varied vegetation (for food and shelter), ample water supplies, and the presence of special habitat features (e.g., rock outcrops, snags, and aquatic habitat) provide the habitat necessary to support a wide variety of wildlife species. In addition, the lack of continuous historic disturbance on the southeast side of Cobb Mountain also positively contributes to the wildlife values of the site.

BIOLOGY TABLE 2

VERY RARE, RARE, AND ENDANGERED PLANT SPECIES (CNPS LIST 2)

<u>Habitat/Species</u>	<u>Rare Plant Status</u>		
	<u>CNPS¹</u>	<u>R-E-V-D*</u>	<u>USFWS^{2*}</u>
<u>SPECIES ON WET SITES</u>			
<u>Blennosperma bakeri</u> Heiser	3-2-2-3		1
<u>Carex albida</u> Bailey	3-3-2-2		1
<u>Dicanthelium acuminatum</u> (SW) Gould & Clark var. <u>acuminatum</u>	3-2-1-3		1
<u>Gratiola heterosepala</u> Mason and Bacig.	3-3-2-3		1
<u>Lasthenia burkei</u> (Greene) Greene	3-3-2-3		1
<u>Lasthenia conjugens</u> Greene	3-2-2-3		1
<u>Legenere limosa</u> (Greene) McVaugh	3-3-3-3		1
<u>Navarretia pauciflora</u> Mason	2-2-1-3		1
<u>Navarretia plieantha</u> Mason	3-2-1-3		1
<u>Orcuttia tenuis</u> Hitchc.	3-3-2-3		1
<u>Parvisedum leiocarpum</u> (H.K. Sharsm.) Clausen	2-2-2-3		1
<u>Perideridia gairdneri</u> (H.&A.) Math. ssp. <u>gairdneri</u>	2-2-2-3		1
<u>Plagiobothrys strictus</u> (Greene) Jtn.	3-2-2-3		1
<u>Poa napensis</u> Beetle	3-3-2-3		1

*See last page of Biology Table 2 for explanation of symbols.

BIOLOGY TABLE 2 CONTINUED

<u>Habitat/Species</u>	<u>Rare Plant Status</u>	
	<u>CNPS¹ R-E-V-D*</u>	<u>USFWS^{2*}</u>
<u>Pogogyne douglasii</u> Benth ssp. <u>parviflora</u> (Benth.) J.T. Howell	2-1-1-3	2
<u>Sidalcea oregana</u> (Nutt.) Gray ssp. <u>hydrophila</u> (Heller) Hitchc.	2-1-1-3	2
<u>SPECIES ON DRY OR MOIST SITES</u> (nonserpentine)		
<u>Astragalus Clarianus</u> Jeps.	3-2-3-3	1
<u>Brodiaea coronaria</u> (Salisb.) Engler ssp. <u>rosea</u> (Greene) Niehaus	3-3-2-3	1
<u>Ceanothus confusus</u> Howell	3-2-1-3	1
<u>Ceanothus divergens</u> Parry	2-1-1-3	1
<u>Eriastrum brandegeae</u> Mason	3-2-2-3	1
<u>Eryngium constancei</u> Sheikh, ined.	3-1-1-3	1
<u>Hesperolinon drymarioides</u> (Curran) Small	2-1-1-3	2
<u>Parvisedum leiocarpum</u> (H.K. Sharsm.) Clausen	2-2-2-3	1
<u>Tracyina rostrata</u> Blake	3-1-1-3	1
<u>SPECIES ON SERPENTINE SITES</u>		
<u>Antirrhinum subcordatum</u> Gray	2-2-2-3	1

*See last page of Biology Table 2 for explanation of symbols.

BIOLOGY TABLE 2 CONTINUED

<u>Habitat/Species</u>	<u>Rare Plant Status</u>	
	<u>CNPS¹ R-E-V-D*</u>	<u>USFWS^{2*}</u>
<u>Cordylanthus tenuis</u> Gray ssp. <u>capillaris</u> (Pennell) Chuang and Heckard, comb. nov. ined.	2-2-1-3	1
<u>Eriogonum nervulosum</u> (Stokes) Reveal	2-1-1-3	2
<u>Helianthus exilis</u> Gray	2-2-2-3	2
<u>Hesperolinon breweri</u> (Gray) Small	2-1-2-3	1
<u>Hesperolinon didymocarpum</u> H.K. Sharsm.	3-2-2-3	1
<u>Streptanthus brachiatus</u> Hoffm.	3-2-1-3	1
<u>Streptanthus morrisonii</u> complex. Hoffm.	2-2-1-3	1

*See last page of Biology Table 2 for explanation of symbols.

BIOLOGY TABLE 2 CONTINUED

RARE BUT NOT ENDANGERED PLANTS (CNPS LIST 3)

<u>Habitat/Species</u>	<u>Rare Plant Status</u>	
	<u>CNPS¹ R-E-V-D*</u>	<u>USFWS²*</u>
<u>SPECIES ON WET SITES</u>		
<u>Cuscuta Howelliana</u> Rubtsoff	1-1-1-3	-
<u>Delphinium uliginosum</u> Curran	1-1-1-3	-
<u>Lepidium latipes</u> Hook	1-1-1-2	-
<u>Ranunculus lobbii</u> (Hiern.) Gray	1-1-1-2	-
<u>SPECIES ON DRY OR MOIST SITES</u> (nonserpentine)		
<u>Antirrhinum virga</u> Eastw.	1-1-1-3	-
<u>Astragalus breweri</u> Gray	1-1-1-3	-
<u>Astragalus clevelandii</u> Gray	1-1-1-3	-
<u>Calochortus pulchellus</u> Dougl ex Benth	1-1-1-3	-
<u>Ceanothus purpureus</u> Jeps.	1-1-1-3	-
<u>Collinsia greenei</u> Gray	1-1-1-3	-
<u>Eriogonum caninum</u> (Greene) Munz	1-2-1-3	-
<u>Erigeron petrophilus</u> (Greene)	1-1-1-2	-
<u>Fritillaria pluriflora</u> Torrey ex Benth	1-2-1-3	2
<u>Lilium rubescens</u> Wats.	1-1-1-2	-
<u>Lomatium ciliolatum</u> Jeps. var. <u>hooveri</u> Math & Const.	1-1-1-3	-

*See last page of Biology Table 2 for explanation of symbols.

BIOLOGY TABLE 2 CONTINUED

<u>Habitat/Species</u>	<u>Rare Plant Status</u>	
	<u>CNPS¹</u> <u>R-E-V-D</u>	<u>USFWS²</u>
<u>Lomatium repostum</u> (Jeps.) Math.	1-1-1-3	-
<u>Lupinus sericatus</u> Kel.	1-1-1-3	-
<u>Mimulus nudatus</u> Curran ex. Greene	1-1-1-3	-
<u>Monardella viridis</u> Jeps. ssp. <u>viridis</u>	1-1-1-3	-
<u>Pityopus californicus</u> (Eastw.) Copel.	1-2-1-2	-
<u>Ribes victoris</u> Greene		-
<u>SPECIES ON SERPENTINE SITES</u>		
<u>Asclepias solanoana</u> Woodson	1-1-1-3	-
<u>Calamagrostis ophitidis</u> (Howell) Nygren	1-1-1-3	-
<u>Collomia diversifolia</u> (Greene)	1-1-1-3	-
<u>Cryptantha hispidula</u> Greene ex. Brand	1-1-1-3	-
<u>Fritillaria purdyi</u> Eastw.	1-1-1-3	-
<u>Hesperolinon adenophyllum</u> (Gray) Small	1-1-1-3	2
<u>Hesperolinon bicarpellatum</u> (H.K. Sharsm.) H.K. Sharsms.	1-1-1-3	2
<u>Navarettia jepsonii</u> Bailey ex. Jeps.	1-1-1-3	-
<u>Nemacladus montanus</u> Greene	1-1-1-3	-
<u>Senecio clevelandii</u> Greene	1-1-1-3	-

Footnotes on next page.

NOTES FOR BIOLOGY TABLE 2

1. California Native Plant Society, Rarity--Endangerment--Vigor--
Distribution (REVD) Code

R (Rarity)

- 1 - rare, but danger of extinction low
- 2 - several populations or one large population
- 3 - one or a few highly restricted populations

E (Endangerment)

- 1 - not endangered
- 2 - endangered in a portion of its range
- 3 - endangered throughout its range

V (Vigor)

- 1 - increasing or stable
- 2 - declining
- 3 - approaching extinction

D (Distribution)

- 1 - widespread outside California
- 2 - rare outside California
- 3 - California endemic

2. United States Fish and Wildlife Service--Federal Register. The species noted are currently under review as Endangered or Threatened.

- 1 - Taxa for which the service has sufficient information to support listing as Endangered or Threatened Species.
- 2 - Taxa for which information indicates probable appropriateness of listing as Endangered or Threatened Species.

*=Panicum thermale Bolander sp. emend. Schmoll. Taxonomic changes are acknowledged; species remains listed pending confirmation of its rarity status.

Mammals are probably well represented on the project site, although no comprehensive studies have been conducted to confirm this. A number of large carnivores, including black bear, mountain lion, and bobcat, have been reported on or immediately adjacent to the leasehold. Other species which are likely to occur on the site include spotted skunk, striped skunk, long-tailed weasel, raccoon, and ringtail. In addition, a large number of small mammals are known or expected to occur on the site and are listed in Appendix E of the AFC.

Aquatic habitat exists within the leasehold on both Anderson and Gunning creeks. According to studies cited in the AFC, there is a rainbow trout fishery in Anderson Creek within the leasehold. Price et al. (1980) found several other fish species occurred downstream from the Occidental site. These include California roach, Sacramento sucker, and riffle sculpin. Similar studies conducted on Gunning Creek indicate that the upper boundary where rainbow trout are no longer found is immediately to the east of the Occidental leasehold (Price et al., 1980). Both the fisheries of Anderson Creek and Gunning Creek are so close to the Occidental leasehold development activity that they are susceptible to major changes in water quality, should such changes occur as a result of this project.

Amphibians and reptiles are probably well represented on the Occidental leasehold. Species which are known to occur in the area include western fence lizard, western rattlesnake, ringneck snake, northern alligator lizard, Pacific giant salamander, insatina salamander, red-bellied newt, and rough-skinned newt.

Numerous bird species are reported to be known or suspected to occur on the Occidental leasehold. These birds generally represent species which are typically found in The Geysers KGRA either as permanent or seasonal residents, or as migratory visitors. A discussion of several bird species appears in the AFC text, and a list of species is available in Appendix E of that document.

Endangered and Fully Protected Species

Only one endangered wildlife species, the peregrine falcon, is known to occur in the KGRA. The peregrine falcon is listed as an endangered species by both the United States Fish and Wildlife Service in 1977 (U.S. Fish and Wildlife Service, 1980) and the California Department of Fish and Game (1978). The legal status and ecological considerations of the peregrine have recently been summarized by the United States Fish and Wildlife Service (1980) and the Pacific Coast American Peregrine Falcon Recovery Team (1980).

Peregrines are known to nest in the Palisades and on Mt. Saint Helena 10 miles south-southeast of the Occidental leasehold. Peregrines have been sighted many times over The Geysers area.

A peregrine eyrie has been reported on Cobb Mountain. However, while several recent peregrine sightings have been reported, studies conducted between 1975 and 1977 which included the Cobb Mountain area found no evidence of nesting (Leitner, 1978). Leitner (1978) indicates that the cliffs on Cobb Mountain are apparently marginal for peregrine nesting. While Occidental leasehold

contains potential foraging areas, the approximate 10-mile distance from the nearest known eyrie makes regular use by those peregrines unlikely.

The golden eagle has been designated as a fully protected bird by the California Fish and Game Commission (1979). Golden eagles have been observed flying over the KGRA, but no eyries are currently known to exist in The Geysers region. It is unlikely that golden eagles would occur on the Occidental leasehold.

Ringtails are also fully protected in California (California Fish and Game Commission, 1979) and are known to occur in The Geysers KGRA. The closest known location to the Occidental leasehold where ringtails have been trapped is just two miles away (Koch and Brody, 1981). Presently, no studies have been conducted on the Occidental leasehold to provide any indication of the ringtail's possible occurrence. Studies on ringtail conducted in The Geysers indicate that this species occurs near riparian zones, often denning in rock outcrops, old stumps, large snags, and living trees. Ringtail may use several dens and have a home range of 400 to 500 acres (1 - 1.5 km²). Individuals may tolerate geothermal development and occur near some developments in The Geysers (Koch and Brody, 1981). The Occidental leasehold includes excellent ringtail habitat, so there is a substantial likelihood that ringtail occur on the site.

Recreational Species

Game species which occur in The Geysers KGRA include mountain quail, valley quail, mourning dove, band-tailed pigeon, western gray squirrel, jackrabbit, brush rabbit, Columbian black-tailed deer, black bear, and rainbow trout. Hunting is a popular sport among the residents in the region, both in season and out of season. Poaching of some species (particularly Columbian black-tailed deer) has been identified as a problem by Energy Commission biologists and the Department of Fish and Game.

Another important recreational aspect of wildlife is the aesthetic value of viewing wildlife in natural settings. The potential for observing wildlife in The Geysers is relatively high when one considers the variety of species which reside in the area. However, due to the limited public access into the area, recreational experiences with wildlife species in The Geysers will undoubtedly continue at extremely low levels.

Species of Special Concern

Species of special concern include candidate rare or endangered species that may need protection from potential adverse effects. Several such species are known or suspected to occur within The Geysers, including the merlin, prairie falcon, Cooper's hawk, sharp-shinned hawk, and long-eared owl. These bird species are discussed in the AFC and by Remson (1978).

While not presently considered rare or endangered, mountain lions are known to occur within The Geysers region. A statewide moratorium on taking mountain lions is currently in effect while the Fish and Game Commission considers various management strategies and future regulations.

IMPACTS

VEGETATION

Impacts to the vegetation resulting from the proposed project will include (1) direct loss of vegetation from construction of the power plant and accessory facilities and (2) vegetation injury and ultimate loss through exposure to cooling tower drift during power plant operation. The increase in human activity associated with construction and operation of the power plant will also result in an increase in fire hazard within the leasehold and to surrounding areas. These impacts are of concern both in terms of the direct loss and cumulative impacts over time within the entire KGRA.

Construction of the power plant, access road and transmission lines will require the removal of approximately 21 acres of native vegetation (Occidental Response to Interrogatories of March 20, 1981). Vegetation loss will be limited to mixed chaparral, chamise chaparral, and serpentine chaparral. These vegetation types are relatively abundant in the region and their loss presents no major impact in and of itself. Still, staff considers the loss of vegetation to be potentially significant as it relates to wildlife, erosion, and rare plant habitat.

The loss of chaparral represents a direct habitat loss for a number of wildlife species. These impacts are described in the section on wildlife.

The power plant construction will result in removal of vegetation from steep slopes on soils known to have high erosion potential. The region's high winter rainfall in combination with these other factors leads CEC staff to believe that there is a high likelihood of losing a relatively large quantity of sediments into the Anderson Creek drainage (see Hydrology section). The effect of erosion resulting from vegetation loss will include potential degradation of water quality (see Water Quality section) and contributes to impacts on aquatic organisms including the recreational fishery of Anderson Creek from the point of disturbance to some potentially great distance downstream (see Wildlife section).

The loss of serpentine chaparral is potentially significant due to the relatively large number of rare plant species which are associated with only this soil/vegetation type. Serpentine chaparral in The Geysers region must be considered to be potentially important rare plant habitat. Staff believes that disturbance of this vegetation type must be kept to an absolute minimum.

Based on past experience in The Geysers steam resource area, operation of the power plant can be expected to result in moderate to severe vegetation stress and injury. Vegetation injury which is attributable to cooling tower drift is visible at virtually every operating power plant and a number of steam wells within The Geysers KGRA. Operating power plants emit a variety of substances from the cooling tower which are potentially toxic to surrounding vegetation. These substances include arsenic, boron, hydrogen sulfide, and mercury. Of these, boron has been identified as the most likely substance responsible for the injured vegetation surrounding power plants and steam wells (Malloch et al., 1979). The observed symptoms on injured vegetation surrounding power plants are nearly identical to those which are generally considered typical for boron toxicity and serves as strong evidence of the cause of injury.

The effects of boron on vegetation include both direct toxic effects and indirect effects which occur as a result of the stress. Direct effects include visible leaf injury and decreased plant vigor. Secondary effects include an increase in the incidence and severity of plant disease due to the weakened state of the plant. The net result can be the loss of vegetation over an area which far exceeds the area disturbed during the power plant construction. Predicting the amount of area which will be impacted by cooling tower drift is extremely difficult. Such calculations require data on the boron content of the cooling tower drift, the meteorological conditions of the site, and the susceptibility of the vegetation on which the drift is deposited. These data are not currently available in quantifiable terms.

The loss of vegetation to cooling tower drift could result in increased impacts to wildlife habitat, and cooling tower drift would be especially threatening to any rare plant species occurring within the drift zone. However, no rare plants are known to occur near to the power plant, and the potential for significant effects on rare plants appears remote.

Construction of the power plant, access road, and transmission line will not directly impact any legally protected species, species of special concern, or species of commercial importance. Other impacts described previously would not be considered significant if proposed mitigation measures are successfully implemented.

WILDLIFE

Impacts to wildlife will result from construction-related disturbance, vegetation loss, and the release of toxic substances. Loss of terrestrial species will be most closely correlated with the amount of vegetation lost, while loss of aquatic species is directly related to the types and amounts of materials entering water courses. The significance of these impacts depends upon the species using the area, the amount of habitat lost, and the value or quality of that habitat. No estimates of current wildlife populations are available; thus, impacts cannot be quantified at this time.

Development at the power plant site will eliminate approximately 21 acres of chaparral. Wildlife species which will be most impacted include the smaller, more sedentary species such as snakes, fence lizards, and salamanders, small birds such as wrentits and rufous-sided-towhees, and small rodents. The loss of these species is not viewed as significant due to their relatively common occurrence in the area and the small number of individuals which are anticipated to be lost. The loss of chaparral has the potential for reducing the number of deer in the area by approximately 8 to 15 individuals (assuming .4 to .7 deer per acre).

Disturbance to wildlife will also result from direct human activity and noise in the area. Noise will be increased at the power plant, along access roads, and along transmission corridors. The extent of impact is uncertain but probably depends on the species which occur in the area. Some species appear to be relatively tolerant of noise and human activity in The Geysers. Other species (including gray fox, bobcat, and mountain lion) may avoid the area entirely.

Aquatic ecosystems are likely to be affected by soil erosion and possible accidental spills and other releases of toxic materials from the proposed project. Sedimentation of Anderson Creek will occur as a result of soil erosion from slopes which have had vegetation removed. Sedimentation can directly impact fish and other aquatic organisms by reducing respiratory function and indirectly by reducing reproductivity. Steel (1977) conducted fishery studies in the KGRA and found significantly higher sediment levels in areas of geothermal development. Trout populations in areas high in sediment were found to be both smaller and in poorer condition. The effect of erosion on aquatic organisms resulting from this project cannot be predicted in quantitative terms at this time.

Accidental spills or other release of materials into streams have occurred repeatedly in The Geysers (CEC staff report in preparation). The results of such spills include large fish kills and impacts to other aquatic organisms. The impact of a toxic spill is determined by the species composition in the stream at the time of the spill, the type of material spilled, and the flow, chemical, and physical composition of the stream. The release of materials can be very detrimental to aquatic species. Since release of toxic materials is not planned (or legally allowed), no estimate of the impact of this plant can be ascertained at this time. However, past experiences with other operators in The Geysers would indicate a strong possibility of toxic spill sometime during the life of this power plant.

The project is not expected to impact either peregrine falcon (endangered) or golden eagles (fully protected). These species are not anticipated to occur on the project site. No disturbance to hunting activities is anticipated as a result of this project.

Use of the leasehold by ringtail is considered likely. Project construction will not eliminate habitat types which staff considers to be ideal for ringtail; however, vegetation loss from operation could affect potential breeding and feeding areas near the power plant. Because no estimates of ringtail populations on the leasehold are currently available, impacts on this fully protected species cannot be determined at this time. Due to the likelihood of ringtail occurring on the Occidental site, it is important to monitor the effects of this development on their well-being.

Recreational species will also be affected by vegetation loss from the power plant construction and operation. The loss of chaparral has the potential to reduce the populations of deer, quail, mourning doves, brush rabbit, and black-tailed hare.

While no single impact of significance has been identified, the total impact of the project on wildlife will be significant unless the impacts caused by the construction and operation of the power plant are mitigated.

MITIGATION MEASURES

VEGETATION

The applicant will revegetate all areas disturbed by the construction of the power plant and access road (Occidental Geothermal, Inc., 1981; Response to

Data Request dated March 20, 1981). Revegetation will be used in conjunction with the physical erosion control measures described in the erosion control plan (Response to Biology Workshop of May 7, 1981). Revegetation with native woody species has been incorporated into this plan and if successfully implemented will help to reduce the loss of native plant communities and at the same time reduce the potential for soil erosion.

The effects of cooling tower drift on vegetation are difficult to mitigate since the extent and severity of injury cannot be predicted. One method of mitigating the effects of cooling tower drift on vegetation is to reduce the amount of drift leaving the cooling tower. Drift eliminators will be incorporated into the power plant design and should reduce drift to the lowest possible levels. There is still a substantial probability of vegetation loss even at these reduced drift levels. In order to quantify the effects of vegetation injury, the applicant shall monitor and report to CEC on the incidence and severity of pollution damage surrounding the power plant. This shall include large-scale color infrared aerial photography coordinated with visual ground inspection of permanent study plots. Specifics of the monitoring program will be described in detail in a separate document.

Impacts on native plant communities will also be lessened through a program of habitat management and enhancement. This will include a regular prescriptive burning program which will maintain a mosaic of vegetation types on the leasehold, reduce the threat of loss from wild fire, and ensure the continued existence and development of native plant communities on the leasehold.

WILDLIFE

The following mitigation measures are proposed to reduce the impact of habitat loss on wildlife species. Where impacts are suspected but unquantifiable, monitoring studies are proposed. In the event severe losses are identified at a later date, mitigation measures are recommended for future implementation if necessary.

Provided the surface owner agrees to such measures, Oxy will mitigate the loss of wildlife habitat through enhancement of existing vegetation and revegetation at disturbed areas with native species valuable to wildlife. Habitat enhancement procedures will include a conversion of old-stand chaparral through the use of prescribed burns on a rotating annual basis for the life of the project. This program will be described in the habitat enhancement plan submitted by Occidental (not yet received). In addition to burning, Oxy will provide protection of existing snags from fire by hand clearing surrounding brush from around the base.

In the event on-site mitigation cannot be implemented, a fee equal to the cost of the full mitigation measure will be paid by Occidental. This money will be used in a manner designated by CEC biology staff for off-site mitigation measures. These could include purchase of unique biological areas, enhancement of wildlife species, preservation of habitat for endangered species, or other steps which will reduce the impact of geothermal development on the region.

The use of native shrubs and trees in revegetation of disturbed areas will also help wildlife by recreating food and cover. Species selected for

revegetation will include those which are valuable to wildlife and for erosion control.

Oxy will conduct monitoring for impacts which have not been clearly determined, due to a current lack of data. They will monitor impacts on aquatic resources on both Anderson Creek and Gunning Creek as described in the May 18, 1981, submittal by Occidental Geothermal, Inc., and subsequently modified by mutual agreement between Occidental and CEC.

Impacts on ringtail are similarly undefined at present. Oxy shall determine the ringtail population on the leasehold before construction, after construction, and during operation of the power plant. The study methods and qualifications of the investigator must be approved prior to the commencement of the studies by CEC biologists and the Department of Fish and Game.

Occidental will implement a study plan to evaluate the effectiveness of the mitigation measures. Reports will be issued to the CEC annually beginning one year after initiation of the mitigation and monitoring plan. Reports on short-lived items (e.g., aquatic monitoring for the first three years) will cease one year after completion. Reports will be supplied annually for the life of the project on those items which last that long (e.g., prescribed burns, revegetation, etc.).

AIR QUALITY

SETTING

The most difficult environmental effects to analyze and evaluate are the impacts of power plant emissions on ambient air quality and the effects that deterioration of air quality has on surrounding plant, animal, and human populations. Several factors account for this difficulty. Some of the most pronounced are:

- a. Reliable up-to-date information on the existing ambient air quality is not always available for the specific plant site;
- b. Prediction of the expected ambient air quality when the project commences operation is difficult and involves many uncertainties;
- c. The current state-of-the-art for predicting the incremental impacts of a project (tracer tests and modeling studies), are not precise, primarily because of the complex terrain and meteorology of The Geysers KGRA; and
- d. Emissions from the power plant are uncertain because the exact composition and concentration of chemicals in the incoming steam are not known.

This section examines available information on ambient air quality at the proposed site, the climatic conditions affecting air quality, available information on steam content, and ambient air quality conditions. The purpose of the discussion is to provide baseline information against which one can measure and evaluate the effects of the proposed project's emissions and their impact on ambient air quality.

CLIMATE

Preproject Meteorological Conditions

Weather conditions in the general vicinity of the site have been monitored at various times for several years. Air quality and meteorological monitoring stations established by the Stanford Research Institute (SRI) are located near enough to the proposed Oxy site so that CEC staff can use data collected there to determine ambient and meteorological conditions at the plant site.*

Station SRI-2 is located on Anderson Ridge (on the same general ridgeline of the Mayacmas Mountains as the plant site), about one mile (1.6 kilometers) southeast of the plant site. Station SRI-6 is located about 3.2 miles (5.1 k) to the east-southeast, near the eastern end of Anderson Springs. Between 1976

*The data and results from all eight of SRI's meteorological stations are contained in a report prepared in November 1979; see Ronald E. Ruff, Leonard A. Cavanaugh, Janet D. Carr, "1978 Executive Summary Specialized Monitoring Services," (SRI International, 1979), hereafter cited as Ruff, Cavanaugh, and Carr.

and 1977 these stations monitored ambient concentrations of hydrogen sulfide (H_2S) and meteorological conditions such as temperature, wind speed, and direction.

Air Quality Figure 1 shows other monitoring stations. The stations were established by SMUD, the California Department of Water Resources, PGandE, Occidental Geothermal, Inc., LCAPCD, and Lawrence Livermore National Laboratory (ASCOT) to provide a more complete and current data base of ambient H_2S concentrations at the KGRA.

Meteorological conditions at the proposed plant site are typical of the climate in the region. Wet winters and dry summers characterize the regional climate. The Pacific High, a semipermanent high pressure system off the Pacific Coast, which influences air flow and precipitation over the entire state, affects the general climate. This high pressure area causes prevailing northwest winds over the KGRA region and the persistent subsidence inversion which extends over much of the state during the summer months.

Ambient Air and Dew Point Temperatures

The complex terrain of the KGRA region is a major factor which affects local climate. The Mayacmas ridge deflects incoming marine air, moderating temperatures within the region. Even so, monthly temperatures at the site can range from 20°F (-6.6°C) in January to over 100°F (37.8°C) in August. Air Quality Table 1 shows monthly average ambient temperatures measured at SRI-2, the NCPA-2 station, and the SMUDGE #1 site. CEC staff believes that these values represent the temperatures at the Oxy #1 site.

Hot summer temperatures contribute to inversion conditions, or "limited mixing," which can "trap" pollutants between the inversion and the ground and intensify concentrations. Limited mixing conditions concentrate pollutants which are released under the stable layer (inversion). The limited mixing condition frequently includes winds which transport the pollutants over the Mayacmas Ridge towards populated areas such as Anderson Springs and Whispering Pines.

The relationships between dew point temperatures and cooling tower plume rise also affect air quality. In general, the lower the dew point temperature, the more slowly the water vapor or steam emitted from a cooling tower plume condenses. The hot vapor or steam can then rise higher and wind streams will disperse it over wider areas. Conversely, when dew point temperature is higher, the water vapor or steam tends to condense more rapidly. Heat energy is lost, the resulting plume rise is lower, and generally dispersion is less extensive.

The effects of dew point temperature on plume rise are not as strong as the effects of wind speed. In fact, mean dew point temperatures recorded at PGandE Geysers Unit 13 (PGandE, 1979d) during 1977-78 have a fairly narrow range of 34°F (November) to 43°F (August). Although a wider range could be expected at the Oxy #1 ridgetop site (Geysers 13 is at a lower, or more sheltered, location), CEC staff does not believe this difference would make dew point the predominant factor in determining plume rise or a major determinant of "worst-case" meteorological conditions for air quality analysis purposes.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

LEGEND

- H₂S SAMPLER AND MECHANICAL WEATHER STATION
- * H₂S SAMPLER ONLY
- MECHANICAL WEATHER STATION ONLY
- ⊖ MECHANICAL WEATHER STATION AND ACOUSTIC SOUNDER

FIGURE 1: AIR QUALITY—Air Quality and Meteorological Monitoring Stations

Air Quality
Table 1

MONTHLY AVERAGE AMBIENT TEMPERATURES IN PROJECT AREA (°C)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anderson Ridge ¹ SRI-2 ¹	7 ⁰	7 ⁰	5.5 ⁰	10 ⁰	18 ⁰	20 ⁰	21 ⁰	22 ⁰	16 ⁰	14 ⁰	10 ⁰	7 ⁰
NCPA-2 ²	-1 ⁰	-1.6 ⁰	2.6 ⁰	4.3 ⁰	11.7 ⁰	13 ⁰	19.3 ⁰	18.4 ⁰	14.9 ⁰	13.6 ⁰	3.4 ⁰	1 ⁰
SMUDGE #1 ³	7 ⁰	5.4 ⁰	5.5 ⁰	10.3 ⁰	12.9 ⁰	14.9 ⁰	22.7 ⁰	22.3 ⁰	19.7 ⁰	13.1 ⁰	8.3 ⁰	8.5 ⁰

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1. Ruff, Cavanaugh and Carr, 1977. Data shown were measured from February 1976 through September 1977.
 2. Environmental Systems and Service (contractor for the NCPA-2 met station). Data shown were measured from April 1978 through March 1979.
 3. SMUDGE #1 AFC, 1980. Data shown were measured from October 1979 through September 1980.

Precipitation

In general, the amount of precipitation can affect the ambient air concentrations of total suspended particulates (TSP). Heavy rains and snow "scrub" or "wash" these particles from the air. Precipitation also helps dissolve certain water soluble gases or particulates emitted from geothermal plants, such as hydrogen sulfide, ammonia, and boron.

Average annual precipitation at the proposed plant site is approximately 80 inches (see Hydrology/Water Quality sections for additional discussion). Winter precipitation often occurs as snow above 2,000 feet (610m) and averages about 20 inches annually. Average relative humidity near The Geysers ranges from about 30 percent during the driest months to near 80 percent in the winter.

The high levels of precipitation during winter months partly account for the fact that the ambient air concentrations of H_2S measured at the SRI stations were generally lower in the winter than in the summer.

Wind Speed and Direction

Wind speed in the project area generally increases with elevation. The proposed project site is at about 3,600 feet elevation. Measurements taken at the meteorological station at the nearby SMUDGE #1 site indicate average wind speeds of approximately 15 mph. SRI data indicate that the frequency of calms (winds less than 1 or 2 mph) is significantly less than 10 percent at exposed elevated peaks. At lower elevations (1,400 to 2,600 feet, elevation of receptors), directional patterns bear little similarity to patterns found at high elevations. Local terrain becomes increasingly important in determining directional distribution. As indicated by the wind rose pattern for SRI-6 (Anderson Springs), there is no dominant wind direction, and this lower elevation exhibits a high frequency of calms, although 1976-78 data would indicate a westerly component.

The directional frequency distribution of local wind flow is more complex. At elevations above 2,000 feet (900m), the predominant wind is either from the NE +45° or the SW +45°. This distribution pattern occurs during all seasons. The likelihood of westerly and southwesterly winds is particularly important, since they can carry emissions from the plant toward Anderson Springs (3.2 miles to the east), Whispering Pines (2.3 miles to the northeast), or down into the Collayomi Valley toward Middletown.

Directional frequency of wind flows at the SRI-2 meteorological station, located on the ridge southeast of the proposed project site, exhibits the typical NE/SW high elevation pattern. Air Quality Figure 2 presents "wind rose" patterns for the SRI-2 site for the years of 1976 and 1977. Air Quality Figure 3 presents wind rose patterns for the SRI-6 (Anderson Springs) site for the period from October 1979 to July 1980. Air Quality Figure 4 also shows wind rose patterns for the SMUDGE #1 site, located northwest of the SRI-2 site on the ridge. Air Quality Table 2 shows the wind speed and direction for ASCOT Station 6 located north of the proposed project site for the year 1979. Comparison of these sets of wind data illustrates the effect of local terrain upon wind direction distribution and frequency.

OXY GEOTHERMAL #1

METERS PER SECOND

Source: SMUDGE #1 AFC

FIGURE 3: AIR QUALITY-Wind Rose, Anderson Springs (SRI-6)
Period of Record 10/4/79 to 7/15/80

OXY GEOTHERMAL #1

FIGURE 4: AIR QUALITY-Wind Rose, SMUD-1 Period of Record 9/26/79 to 11/30/79

Air Quality

Table 2

ASCOT STATION 6 WIND DIRECTION AND SPEED
 FREQUENCY DISTRIBUTION (PERCENT) AND AVERAGE WIND SPEED (MPH)
 AUGUST 1979 THROUGH NOVEMBER 1979

Wind Direction	Percent of Time Wind Speed is Between						Avg. Wind Speed
	1-3	4-7	8-12	13-18	19-	Total	
NNE	0.8	1.8	0.3	0.0	0.0	2.9	5.0
NE	1.6	2.7	1.3	0.1	0.1	5.8	6.2
ENE	1.7	1.5	1.0	0.0	0.0	4.2	5.0
E	3.9	9.5	2.4	0.0	0.0	15.8	5.4
ESE	2.3	6.0	2.1	0.2	0.0	10.6	5.6
SE	1.4	0.4	0.0	0.0	0.0	1.8	2.9
SSE	0.7	0.3	0.0	0.0	0.0	1.0	3.2
S	1.1	0.0	0.0	0.0	0.0	1.1	2.0
SSW	0.5	0.0	0.0	0.0	0.0	0.5	1.8
SW	1.0	1.5	0.2	0.0	0.0	2.7	4.7
WSW	1.8	2.1	0.6	0.0	0.0	4.5	4.7
W	2.0	6.1	0.7	0.0	0.0	8.8	5.1
WNW	3.5	13.4	8.2	2.6	0.0	27.7	7.1
NW	1.8	2.9	2.2	0.5	0.0	7.4	6.5
NNW	0.9	1.0	0.7	0.0	0.0	2.6	5.1
N	1.0	1.5	0.1	0.0	0.0	2.6	5.1
Total	26.0	50.7	19.9	3.4	0.1		

4 month average wind speed = 4.7 mph

Source: Lawrence Livermore Laboratory, 1980.

Topographic features may cause channeling of moderate or strong flows within valleys and around obstacles. Heating and cooling of slopes tend to create upslope flows over sun-heated surfaces and downslope flows at night. Downslope drainage flows are mostly developed in winter and upslope flows are strongest and most frequent in summer.

Worst-Case Meteorological Conditions

Several studies were conducted for other CEC regulatory cases to determine worst-case meteorological conditions. SRI's study established a data base for determining the predominant meteorological conditions at several points in the KGRA, including ridgetop and valley locations. An objective of this project was to provide data to help clarify correlations between specific conditions, such as temperature and wind speed/direction, and the high H₂S concentrations which have been recorded.

This data base, subsequent analyses, and field tracer tests did not result in definitive relationships between particular sources (power plants) and the receptors which they affect. Therefore, Occidental conducted tracer tests for the limited mixing and downwash regimes (see Impacts and Mitigation Measures). The purpose of tracer tests is to determine transport and dispersion of a plume under the conditions recorded on that test day. However, those conditions may not result in worst-case impacts. Therefore, Occidental used a model simulation to extrapolate tracer test meteorology to worst-case conditions (by changing some parameters) to estimate expected worst-case air quality impacts at receptors.

The Oxy Geothermal Plant #1 could affect receptor areas under the following meteorological conditions (see Impact section for discussion of potential impacts):

- a. Limited Vertical Mixing: a layer of stable air above the Mayacmas Ridge (which reduces the total volume of air for dispersion and concentrates the pollutant) coincident with cross ridge winds, which transport the plume into Lake County receptor areas.
- b. Downwash: high speed ridge winds deflect the plume downward by mechanical fluid motion into an adjacent valley (either Alexander Valley or the Anderson Springs/Whispering Pines area).
- c. Drainage: surface cooling and light winds aloft can carry the plume over the ridge into Big Sulfur Creek or down into Lake County around daybreak.
- d. Fumigation: transportation of plumes via a neutral or stable layer to Alexander Valley, where drainage winds and subsequent convective mixing at sunrise carry pollutants to the ground. Fumigation may also occur in the afternoon because of valley shadowing causing indirect circulation.

Air Quality

Geothermal steam emissions predominantly influence ambient air quality in the region. Water vapor constitutes about 99.5 percent of these emissions;

condensable gases (other than water vapor), noncondensable gases, and solids comprise the remaining .5 percent.

Characteristics of Steam Content as They Relate to Air Quality

Composition of the steam varies according to the location of the source within the KGRA. Air Quality Table 3 presents a comparison of the composition of geothermal steam produced from wells supplying earlier PGandE units and one which will supply the Oxy #1 power plant. The figures in this table identified as The Geysers represent averages based on the range of values measured for several producing steam wells in the KGRA.

As the table demonstrates, the concentration of regulated pollutants in the steam from the Occidental well is generally much lower than the average concentrations from other geothermal projects. Two wells have been drilled, but only one of Oxy's wells has been tested at this time. Operation of the plant will require a total of 7 - 12 wells. Thus, the CEC staff can reach no firm conclusion about ultimate concentrations of these pollutants. However, information from wells drilled for nearby units (PGandE Units 9 and 10, 13, 16, and 18, and SMUDGE) suggests that the concentrations of pollutants in the southern part of the KGRA will be less than that seen in most other developed areas of the KGRA. These facts imply a greater likelihood of the Oxy #1 project meeting air quality standards as well as a greater likelihood of avoiding adverse environmental impacts than units located in other parts of the KGRA.

Characteristics of Existing Ambient Air Quality

As geothermal development in the KGRA increases, observation of ambient air quality and meteorological conditions at key locations becomes more critical to ensure attainment and maintenance of the ambient air quality standards.

In 1975, the California Air Resources Board measured seven major air quality contaminants at two sites in southern Lake County. The two sites were Kelseyville, about 10 miles northwest of the site, and Middletown, about 5 miles to the west. The ARB monitored ozone, carbon dioxide, sulfates, total hydrocarbons, methane, nonmethane hydrocarbons, and coefficient of haze (reduced visibility). According to the ARB, the California Ambient Air Quality Standards (CAAQS) for each of these parameters were not exceeded during the monitoring period of April 14 through May 12, 1975. No similar or more recent monitoring for the parameters has been undertaken, despite the increase in geothermal development since 1975.

Pollutants associated with development of geothermal resources which are of concern in maintaining ambient air quality include suspended particulate matter, hydrogen sulfide, sulfur dioxide, and radon. The following discussion describes ambient air conditions for each of these pollutants.

Total Suspended Particulate Matter (TSP)

Lake and Northern Sonoma County Air Pollution Control Districts conducted a six-month program to monitor suspended particulate matter in the region. During the period of February through August 1977, suspended particulate

Air Quality

Table 3

NONCONDENSIBLE GASES AND SOLIDS IN STEAM (AVERAGED) FROM WELLS SUPPLYING GEOTHERMAL POWER PLANTS

Percent by Weight		
<u>Noncondensible Gases</u>	<u>The Geysers*</u>	<u>Oxy #1**</u>
Carbon Dioxide	0.3260	0.5000
Hydrogen Sulfide	0.0222	0.0090+30
Methane	0.0194	0.0390
Ammonia	0.0194	0.0033
Nitrogen	0.0052	0.0210
Hydrogen	0.0056	0.0034
Ethane	Negl	Negl
<hr/>		
Total Noncondensibles	0.398	0.5757
<u>Solids</u>		
Arsenic***	0.019	0.004
Boron***	16.0	1.0
Mercury***	0.005	0.0077
Silica (SiO ₂) ***	No Data	0.07

-
- * Overall average from 61 producing wells supplying The Geysers Power Plant, measured in 1972 - 1974 (NSCAPCD, 1974). Characteristic of wells change with time, validity of 1972 - 1974 data may be questionable.
- ** Based on one well proposed to supply Oxy #1; measured by Occidental Geothermal Inc.
- *** Parts per million, by weight.

matter concentrations averaged over 24 hours ranged from 1.74 ug/m³ on Socrates Mine Road (March 14, 1977) to 76.05 ug/m³ in Middletown (August 11, 1977). The higher values observed in Middletown probably reflect the contributions from nongeothermal sources in Middletown, such as vehicular traffic, construction activities, and agricultural activities.

All reported concentrations are below the California Ambient Air Quality Standard for TSP of 100 ug/m³, averaged over 24 hours.

Hydrogen Sulfide (H₂S)

As part of its study, SRI measured ambient concentrations of H₂S at eight locations in the region from 1976 to 1978. SRI then derived hourly averaged concentrations of H₂S. Air Quality Figures 5 and 6 and Table 4 present the distribution and frequency of times when the state ambient H₂S standard (.03 ppm) was equalled or exceeded* at each monitoring point during 1976-77 and during 1978. Indicated violations by today's interpretation of the standard may be underestimated; e.g., the ARB has determined that concentrations which equal or exceed 25 ppb constitute violations (ARB Letter, Thomas Austin to Michael Tolmasoff, dated April 2, 1980).

The SRI data near the proposed site indicate that the H₂S levels at Geysers Rock (SRI-1) and on the ridge crest above Anderson Springs (SRI-2) are somewhat higher than those of other monitored areas. Both sites are near producing geothermal fields. SRI-2 is the monitoring station nearest the proposed project site (1.0 mile to the southeast). The data indicate that 1976 H₂S levels at this site exceeded the state standard approximately 10 percent of the time (640 hours from a total of 7,325 hours monitored). During 1977, the 30 ppb standard was exceeded approximately 5 percent of the time (360 hours from a total of 8,372 hours monitored).

SRI-2 generally records high H₂S levels when the winds are from the southwest. The distribution of H₂S concentrations versus time of day also peak during the night or early morning hours. Probably natural fumarole activity, coupled with emissions from geothermal development activities (operating PGandE units and wells) to the southwest of Cobb Mountain, is the primary contributor to H₂S concentrations recorded at SRI-2 during west or southwest winds.

Data from SRI-6 for 1977, located below the ridge in Anderson Springs, indicates that the state standard was exceeded about .3 percent of the time (25 out of 8,201 hours monitored). Most of the violations in 1977 occurred during evening hours with low southwesterly winds. For SRI-2 and SRI-6, Air Quality Figures 7, 8, and 9 provide H₂S data for each major wind direction, indicating the percentage of time various wind speeds occurred and the percent of time various levels of H₂S occur.

Air Quality Table 5 shows the results of the SMUD-DWR monitoring program conducted in 1979 and 1980. The data for Anderson Springs indicate relatively low H₂S concentrations. This may be due to unusual meteorology during 1980 or the fact that the monitor was removed in June 1980, before that time of the year in which excessive H₂S concentrations historically occur. The

*A violation of a state ambient standard occurs if the measured ambient concentration of a pollutant equals or exceeds that standard.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 5: AIR QUALITY—Distribution of H₂S Hourly Average at or Above 30 ppb

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 6: AIR QUALITY—Distribution of H₂S Hourly Average at or Above 30 ppb (Concluded)

OXY GEOTHERMAL # 1

POLLUTANT : H2S
STATION CODE : SRI 2
SAMPLING PERIOD : 76-32 TO 77-366

SHADE CONCENTRATION (PPB) NO. OF SAMPLES

ABOVE 25.0	1284
BETWEEN 10.0 AND 25.0	2737
BELOW 10.0	10482
ALL	14503

Source: SAI (Oct. 1980)

FIGURE 7: AIR QUALITY—Historical H₂S Levels at SRI-2 (1976-1977)

OXY GEOTHERMAL #1

POLLUTANT : H₂S
STATION CODE : ANDERSON SPRINGS
SAMPLING PERIOD : 76-32 TO 78-366

SHADE	CONCENTRATION (PPB)	NO. OF SAMPLES
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	ABOVE 25.0	62
	BETWEEN 10.0 AND 25.0	806
	BELOW 10.0	20874
	ALL	21742

Source: SAI (Oct. 1980)

FIGURE 8: AIR QUALITY-Historical H₂S Levels at Anderson Springs (1976-1978)

OXY GEOTHERMAL #1

POLLUTANT : H2S
STATION CODE : ANDERSON SPRING
SAMPLING PERIOD : 79-278 TO 80-167

SHADE	CONCENTRATION (PPB)	NO. OF SAMPLES
ABOVE 25.0	0
BETWEEN 10.0 AND 25.0	9
BELOW 10.0	4486
ALL	4495

Source: SAI (Oct. 1980)

FIGURE 9: AIR QUALITY-Historical H₂S Levels at Anderson Spring (1979-1980)

Air Quality

Table 4

DISTRIBUTION OF H₂S HOURLY AVERAGES (30 ppb): 1978

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
1 Geyser Rock	≥30 ^a	5	2	1	14	1	23	56	28	7	23	12	16	188	2
	Days ^b	1	2	1	7	1	9	18	11	5	9	7	8	79	22
	Counts ^c	597	602	719	675	691	590	723	687	612	724	558	657	7835	89
2 Anderson Ridge	≥30 ^a	3	1	2	1	13	84	62	22	33	23	10	46	300	4
	Days ^b	2	1	2	1	6	18	14	7	14	13	6	16	100	27
	Counts ^c	600	539	712	679	676	575	591	481	497	596	659	711	7316	84
3 Kahm Ranch	≥30 ^a	0	0	0	0	0	0	0	1	0	1	0	0	2	0.03
	Days ^b	0	0	0	0	0	0	0	1	0	1	0	0	2	0.5
	Counts ^c	470	605	727	673	694	645	719	710	700	682	372	578	7575	86
4 Pine Summit	≥30 ^a	0	0	0	0	0	3	18	18	10	14	0	0	63	0.9
	Days ^b	0	0	0	0	0	1	7	8	6	5	0	0	27	8
	Counts ^c	607	595	611	692	335	646	714	728	712	547	242	553	6982	80
5 Whispering Pine	≥30 ^a	0	1	7	2	0	0	3	0	3	6	3	0	25	0.3
	Days ^b	0	1	5	1	0	0	2	0	2	4	3	0	18	5
	Counts ^c	562	571	687	683	698	634	723	716	666	648	537	420	7545	86
6 Anderson Springs	≥30 ^a	0	0	0	0	0	2	0	2	0	0	0	0	4	0.05
	Days ^b	0	0	0	0	0	1	0	2	0	0	0	0	3	0.8
	Counts ^c	587	601	609	689	705	645	726	719	690	687	697	742	8097	92
7 Sawmill Flats	≥30 ^a	0	0	0	0	0	1	3	0	0	4	0	0	8	0.1
	Days ^b	0	0	0	0	0	1	2	0	0	2	0	0	5	1.4
	Counts ^c	605	613	734	655	696	646	725	719	710	331	380	725	7539	86
8 Aidlin Ranch	≥30 ^a	12	9	0	0	0	0	66	41	7	94	62	9	300	6
	Days ^b	9	6	0	0	0	0	16	10	3	17	10	6	77	21
	Counts ^c	552	358	0	0	0	0	673	689	677	592	501	716	4758	54
Monthly totals:	≥30	20	13	10	17	14	113	208	112	60	165	87	71	890	
	≥30	12	10	8	9	7	30	59	39	30	51	26	30	311	

a ≥30 ppb = number of H₂S hourly averages at or above 30 ppb. (The actual measurement per hour must have averaged 29.5 or more.)

b Days = number of days with at least one hour reading at or above 30 ppb.

c Counts = number of valid hourly averages (percent counts correspond to valid data capture for 1 January through 31 December).

Source: Ruff and Cavanaugh (1979)

Air Quality

Table 5

SMUD/DWR MONITORING DATA

Monitor	Period of Record (Julian Date)	H ₂ S Concentration (ppb)		
		Highest	Second Highest	Number of Exceedances
Anderson Springs	4 October 1979- 26 June 1980	14	11	None
Geysers Rock	8 August 1979- 16 August 1980	90	88	59
Pine Summit	11 August 1979- 16 August 1980	33	28	2
Jimtown	10 October 1979- 15 July 1980	18	12	None
Geyserville	14 August 1979- 23 August 1980	93	82	30
Hobergs	21 November 1979- 1 July 1980	29	25	2
Big Sulphur Creek	13 August 1979- 8 August 1980	210	170	92

Source: SAI Report, "Assesment of The Sacramento Municipal Utility District's Proposed Geothermal Power Plant -- Volume III. Final Worst-Case Air Quality Analysis", October 3, 1980.

LCAPCD Anderson Springs H₂S monitor measured one H₂S standard violation during the five-month period of July through November 1980.

PGandE indicated in their Quarterly Progress Report for Geysers Unit 17 (79-AFC-1) August 1, 1980, through October 31, 1980, that Environmental Systems and Services (ESandS) is operating (under contract with NSCAPCD) the ambient air quality monitoring station at the SRI-4 site. ESandS indicates that except for one reading of 28 ppb on July 30, 1980, at 2200 hours, all recorded H₂S concentrations at the SRI-4 site during 1980 were less than 20 ppb as of October 31, 1980. If the July 30, 1980, reading of 28 ppb were rounded per the ARB criteria, this reading would constitute a violation of the ambient air quality standard for H₂S. PGandE, in their Quarterly Progress Report for February 1, 1981, through April 30, 1981, reported 1 violation of 50 ppb at SRI-4 (January 6, 1981, at 2000 hours). PGandE also reported that most of their units were either down for repairs or overhaul just prior to or during this period.

Data from the PGandE/ARB monitoring station at Whispering Pines showed no violations from August through September 1980 (Oxy AFC). The Oxy aerometric station at Starview, on Boggs Mountain above Whispering Pines, recorded no H₂S concentrations above 5 ppb from August 1980 through January 1981 (Oxy AFC).

It is extremely difficult to determine the exact sources of H₂S during periods when state standards are violated. The total existing Geysers geothermal development contributes to these violations. Winds west of the Mayacmas ridge carry H₂S emitted from the plants and steam fields over the ridge crest. Drainage flow downslope could subsequently dominate this wind flow and cause pollutants to move toward Anderson Springs.

Sulfur Dioxide (SO₂)

As part of its study, SRI measured SO₂ concentrations at Anderson Springs (SRI-6) and Pine Summit (SRI-4). They took over 7,000 measurements (hourly average) at each station between February and December 1976. At no time did SO₂ concentrations ever exceed the state standards for SO₂ (0.5 ppm hourly average or 0.05 ppb 24-hour average). In fact, only rarely (1.1 percent of the time) did the hourly average concentrations of SO₂ at Anderson Springs exceed .005 ppm.* Thus, SO₂ concentrations are not expected to approach or exceed ambient air quality standards.

*See Ruff, Cavanaugh, and Carr, page 6, Table 3, Distribution of SO₂ Hourly Averages, 1976.

AIR QUALITY

IMPACTS

CLIMATE

Persistent emissions of heated water vapor can affect several microclimate variables. Addition of this vapor to the atmosphere slightly increases ambient temperature and humidity and reduces insolation (incoming solar radiation). CEC staff does not expect emissions from the proposed project to significantly affect local humidity and temperature, due to the relatively low volume of emissions in relation to the absorption capacity of the overlying air mass.

During calm winter nights when drainage or downslope wind flows predominate, emissions of water vapor may slightly increase the frequency and duration of fog within one-half to one mile of the proposed project site.

AIR QUALITY

Legal Requirements

Lake County Air Pollution Control District (LCAPCD):

Rules 602, 604 and 605 (New Source Review)

LCAPCD Rules 602 and 605 require that the Air Pollution Control Officer (APCO) perform an air quality analysis for any source which will emit more than 20 pounds per hour or 150 pounds per day of any pollutant, except CO, for which there is a local, state, or federal ambient air quality standard (AAQS). The APCO must deny an authority to construct for such a source unless he determines that emissions from the source may not be expected to result in the violation or measurable contribution to the continued violation of any AAQS and provided that BACT will be used on the contaminant-emitting equipment for any pollutants for which there is an AAQS. Further, Rule 604 allows the APCO to conduct an air quality analysis for a source which will emit less than 20 pounds per hour or 150 pounds per day of any pollutant for which there is an AAQS if the emissions from the source may be expected to result in the violation or measurable contribution to the continued violation of an AAQS.

If an analysis performed pursuant to LCAPCD Rule 605 indicates the source will result in the violation or measurable contribution to the continued violation of an AAQS, Rule 602-B provides that the APCO may still permit that source if emissions offsets, beyond those reductions required by existing control strategies, are obtained in such an amount that a "demonstrable basin-wide air quality benefit" will result.

Rule 608

Notwithstanding Rules 602, 604, and 605(c), Rule 608 allows the LCAPCD to permit a facility, provided the facility uses best available control technology (BACT) and meets the following prescriptive criteria:

- o Power plants and geothermal fluid transmission lines must limit on a continuous basis the hydrogen sulfide emission rate to no more than five pounds per hour (5 lbs/hr) per one million pounds per hour of steam flow received.
- o The power plant is not located within 0.6 miles of a permitted geothermal power plant (within the district) and is not located within 1.0 miles of a populated area [as defined in Chapter 21 of the Lake County Code, Article XXV, Section 21-73.6a(1)].
- o Geothermal development wells must limit the hydrogen sulfide emission rate on a continuous basis during air drilling, cleanout, initial testing, and reworking to no more than five (5.0) pounds per hour (2.3 kilograms per hour).
- o Venting wells on standby shall be located no closer than 0.5 mile from a populated area [as defined in Chapter 21 of the Lake County Code, Article XXV, Section 21-73.6a(1)], and emissions shall be no greater than an average of one (1) pound per hour per well based on the number of completed wells for the associated power plant's steam field.
- o In the judgment of the APCO the facility must readily be able to show compliance with all other rules and regulations which limit emissions other than hydrogen sulfide.
- o No individual property owner or legal resident within a one-mile radius of the proposed power plant site makes a request for a New Source Review of the project.

Rule 421.2.A

LCAPCD Rule 421.2.A (as revised April 7, 1981) limits H₂S emissions from a geothermal power plant which receives an Authority to Construct on or after January 1, 1981, to not more than 50 grams per gross megawatt hour (g/GMWh). H₂S emissions from all geothermal power plants located in Lake County will be limited to 50 g/GMWh beginning January 1, 1990, subject to a public hearing in 1987.

Rule 411

LCAPCD Rule 411 limits emissions of particulate matter to whichever is the lesser of:

- a. 0.2 grains per standard cubic foot of gas, or
- b. 40 pounds per hour.

Rule 412

LCAPCD Rule 412 limits emissions from any sulfur recovery unit producing elemental sulfur to the following:

- a. 300 PPMV of sulfur compounds calculated as SO₂,

b. 10 ppm H₂S by volume, and

c. 100 pounds per hour of sulfur compounds calculated as SO₂. The APCO interprets Rule 412 as applying to Stretford and EIC units.

Rule 430

A general emissions limitation contained in LCAPCD's Rule 430 prohibits the discharge of any contaminant in an amount which causes injury, detriment, nuisance, or annoyance to any considerable number of persons or which causes injury or damage to business or property.

State

The state AAQS for H₂S is 0.03 ppm. The California Air Resources Board (ARB), which sets and enforces state AAQS, determined that ambient concentrations of H₂S which equal or exceed 25 ppb (0.025 ppm) constitute violations (ARB Letter, Thomas Austin to Michael Tolmasoff, dated April 2, 1980). The Public Health Section of this EIR identifies the state AAQS for other pollutants.

Federal

Prevention of Significant Deterioration (PSD) regulations apply to construction of new facilities in areas which currently meet air quality standards. PSD regulations establish the acceptable levels of deterioration in these areas based on the classification of the area. National Parks and Wilderness areas are Class I areas, where practically any deterioration is significant. PSD regulations allow some deterioration in Class II areas. The proposed project is located in an area presently designated as Class II. The nearest Class I area to the site is approximately 50 miles to the north. PSD regulations also can require the application of BACT, as defined by federal law, to sources of certain pollutants.

Emission Sources

A typical geothermal power project can emit air pollutants from two principal sources: (1) the power plant itself and (2) the steam wells and steam transmission lines. The first source produces emissions during routine operation of the steam turbine-generator, while the latter sources produce significant emissions only when the steam turbine-generator shuts down and steam vents (stacks) directly to the atmosphere. Emissions from the power plant are from two major points: (1) the noncondensable gas stream from the condenser and (2) the cooling tower.

The two most important air pollutants Oxy #1 will emit are hydrogen sulfide (H₂S) and particulates (total suspended particulates or TSP). Both pollutants are present in the incoming steam and must be controlled. Occidental proposes the Stretford process to control H₂S emissions from the noncondensable gas stream and the Hydrogen Peroxide (with or without catalyst) secondary abatement process to control the H₂S emissions from the cooling tower. Occidental is investigating alternative secondary controls. Oxy #1 will also use dual turbines and a turbine bypass mechanism which will significantly reduce stacking occurrences and corresponding emissions. SMUDGE #1 and DWR Bottle Rock are the only other new plants currently committed to use of the bypass mechanism.

In addition, the steam transmission line can emit small quantities of pollutants from well bleedlines, leaky gaskets, or the clean-out of particulate collectors. These emissions are continually released throughout the leasehold, but are so low that the regulatory agencies generally consider their impacts insignificant.

Particulate Sources and Quantities

The major sources of particulate emissions from the Oxy facility will be the geothermal steam and the H₂S abatement system's chemicals and reaction products. The geothermal steam, after passing through the turbine, will be condensed in the unit condenser. In the condenser, the particulates in the steam will be separated into the liquid and noncondensable gas streams. The liquid stream will be transported to the cooling tower with the circulating cooling water, where a portion of the particulates will be emitted to the atmosphere in the form of drift. The remainder will be reinjected with the blowdown from the cooling tower to the geothermal reservoir. The particulates in the noncondensable gas stream will be transported to the Stretford unit, where some of them will be scrubbed out by the Stretford solution. The Stretford chemicals, however, are an additional source of particulates. The noncondensable gas stream, after treatment by the Stretford unit, will carry these particulates to the main power plant cooling tower, where they will be emitted to the atmosphere. The secondary abatement process will use hydrogen peroxide, which, when combined with the H₂S and ammonia in the condensate, will form ammonium sulfate which can be emitted as a particulate. The chemical reaction may also form other solids.

Occidental estimated the Total Dissolved Solids (TDS) and the Total Suspended Solids (TSS) in the circulating water to be 300 ppmw and 100 ppmw respectively (this is based on a concentration factor of 3.94). Occidental also estimated the TDS contribution from the secondary Hydrogen Peroxide process to be 350 ppmw. Based on a drift rate of 0.001 percent, the assumption that both TDS and TSS will form particulate emissions and a circulating water flow rate of 80×10^6 lbs/hr, the circulating water contribution of particulates is 0.6 lbs/hr.

Occidental estimated that mist eliminators on the Stretford process will reduce the carry-over of Stretford chemicals to approximately 0.002 percent of the solution flow rate or approximately 22.6 pounds per hour of liquid. The Stretford solution may contain up to 30 percent dissolved solids. Therefore, the Stretford process will contribute approximately 7 lbs/hr particulates in the noncondensable gas stream. Occidental also indicated that if an oxidizer and evaporator (Stretford cooling tower) are used, the Stretford process will emit an additional 15.1 pounds per hour.

The total particulate emission rate from the proposed facility, assuming an evaporative cooler, is 22.6 pounds per hour or 0.0001 grains per standard cubic foot, (based on a air flow rate through the cooling tower of 53.2×10^6 pounds per hour). This emission rate would comply with LCAPCD Rule 411.

Hydrogen Sulfide Sources and Quantities

The H₂S in the steam supply, after it is exhausted by the turbine, separates (partitions) into both the noncondensable gas stream and the liquid stream.

The proposed power plant will emit H_2S in the noncondensable gas stream and from the cooling tower. H_2S entrained in the liquid condensate will then enter the atmosphere. If these emissions were left untreated, they would contribute significantly to violations of applicable standards for H_2S . For this project (as in other recently proposed projects), Occidental proposes the Stretford process to abate H_2S in the noncondensable gas stream and the Hydrogen Peroxide process to abate the H_2S entrained in the liquid condensate. CEC staff expects the Stretford process to have a control efficiency of approximately 99 percent of the H_2S it receives. The Ralph M. Parsons Corporation, manufacturer of the Stretford units for PGandE's Geysers Units 15, 17, and 18, now offers guarantees that the treated gas stream leaving its Stretford unit contains no more than 10 ppmv H_2S . The Hydrogen Peroxide process is capable of control efficiencies in the range of 95 percent to 98 percent of the H_2S it receives.

The success of the H_2S abatement systems depends in part on the partitioning efficiency achieved in the surface condenser. The partitioning efficiency obtained at PGandE Unit 15 was approximately 65 percent. The partitioning efficiencies obtained at PGandE Units 13 and 14 were in the range of 80 percent to 90 percent. Partitioning efficiency depends to a large extent on the incoming steam constituents and the condenser design. Since Oxy #1 is located in the same general area as Units 13 and 14, it might be expected that the steam constituents and the partitioning efficiency would be similar. However, for the purposes of a worst case assumption, the CEC staff will assume the partitioning efficiency is 65 percent.

Based on the limited data from the initial Occidental steam well, the range of H_2S concentrations in the incoming steam is 90+30 ppmw (Oxy AFC Table 1.2-3). The total amount of H_2S entering the plant, based on an expected incoming steam flow of 1.5×10^6 pounds per hour, would range from approximately 90 to 180 pounds per hour.

Occidental initially proposed a 9.7 pounds per hour (50 g/GMWh) H_2S emission rate for their project. Since the initial AFC filing, LCAPCD adopted Rule 608, which limits H_2S emissions to 5 lbs/hr per million pounds steam input. Occidental applied for a permit under Rule 608 (letter, June 26, 1981, Bob Ward to Bob Reynolds, LCAPCD, Application under Rule 608 for Authority to Construct.) For the Oxy #1 project, Rule 608 limits the H_2S emissions rate to 7.5 pounds per hour, based on 1.5×10^6 pounds per hour steam input.

Based upon the above Stretford (99 percent) and Hydrogen Peroxide (95 percent) control team efficiencies and the worst-case assumed partition efficiency (65 percent), the proposed control would be capable of abating H_2S emission to 4.6 pounds per hour (based on the highest input rate of H_2S of 193 pounds per hour). Thus, the proposed controls would be capable of meeting LCAPCD Rules 608 and 421.2.A.

Occidental is currently investigating alternative secondary abatement systems. These systems are Condensate Stripping and Condensate pH Control. Condensate Stripping and Condensate pH Control would increase the partitioning efficiency obtained in the surface condenser. Application of these controls would send the additional H_2S to the Stretford unit for abatement.

The Condensate Stripping process uses an inert gas to drive H_2S from the condensate. The stripping gases move up a vertical column (stripping tower) while the condensate flows down through the column. The stripper gas contains

carbon dioxide which reacts with the ammonium and hydrogen sulfide in the condensate and results in hydrogen sulfide gas formation. The Stretford unit will then oxidize the hydrogen sulfide gas. Condensate pH control (Ammonia Fixation) increases partitioning in the condenser by affecting the chemical balance during condensation. This control manufactures carbonic acid from the noncondensable gas leaving the Stretford unit. The carbonic acid is injected into the condenser where it reacts with the ammonia in the steam and reduces the amount of hydrogen sulfide in the condensate. Preliminary technical and economic analyses of the condensate stripping and condensate pH control techniques encouraged Occidental to further investigate these methods under bench scale testing. Occidental agreed to use hydrogen peroxide with ferrous sulfate and hydroxyacetic acid for condensate treatment. If tests of alternatives are positive, Occidental may modify the design with LCAPCD and Commission approval. However, currently, there is insufficient data to approve either alternative control.

Sulfur Compound Sources and Quantities

The Stretford unit will emit the byproducts sodium sulfates and thiosulfates as entrained aerosols and small amounts of H_2S in the treated gas stream. Up to 28 percent of the Stretford solution may be sodium sulfate and thiosulfate. Sodium sulfate and thiosulfate emissions as aerosols will be approximately 4.0 pounds per hour, calculated as sulfate, SO_4^{2-} .

The treated gas stream from the Stretford unit will contain 0.1 percent of the inlet H_2S . Assuming 65 percent partitioning and 120 ppmw H_2S in the steam, the effluent H_2S would be 0.12 lb/hr. The total sulfur compound emissions from the Stretford unit, calculated as SO_2 , would be 2.9 lb/hr. This latter figure is well below the limit of 100 pounds per hour set by Rule 412C.

Stretford sulfur compound emissions from the cooling tower would be about 0.018 ppmv, calculated as SO_2 . Sulfur compound emissions from the Stretford oxidizer and evaporator, if one is used, would be about 21 ppmv. Both emissions are well below the standard of 300 ppmv set by Rule 412A.

Stretford H_2S emissions of 0.0022 ppmv from the cooling tower are far below the standard of 10 ppmv set by Rule 412B.

Ambient Air Quality Impact

Systems Applications, Incorporated (SAI), investigated air quality impacts at nearby receptor areas due to the projected emissions from Oxy #1. SAI's impact assessment integrated field tracer tests with computer modeling. The objective of this approach was to incorporate real-world information from the tracer studies into a mathematical computer simulation. Also, the results of the tracer studies provided a baseline against which the modeling results could be compared. After making these comparisons to improve model performance, SAI expected the model to be capable of predicting ambient air quality at The Geysers when Oxy #1 begins operation in 1984.

Four components were used to predict the incremental impacts from Oxy #1:

1. Tracer Tests--Gases were released under two candidate worst-case weather conditions (i.e., limited mixing and downwash) under which Oxy #1 would most likely affect receptor areas. Detectors in these areas indicated cumulative hourly concentrations of tracer gases.
2. SAI Model Simulation--The SAI Geysers Hybrid Model was used to simulate the Oxy #1 limited mixing tracer test. This enabled SAI to calibrate the model so it would provide results similar to values measured in the tracer test. The input parameters were then varied in order to examine possible worst-case impacts.
3. Comparison with SMUDGE #1 Incremental Impacts--The CEC staff examined the SMUDGE #1 tracer test results and modeling studies, because the SMUDGE #1 facility is relatively close to the Oxy site.
4. SAI Simulation of the July 28, 1976 Worst-Case Day--Meteorological data from July 28, 1976, were used to simulate the incremental impact from Oxy #1.

Limited Mixing Incremental Impact

Based on a worst-case emission rate of 9.7 pounds H_2S per hour, SAI* determined peak H_2S concentrations (summarized in Air Quality Table 6). Air Quality Table 6 shows SMUDGE #1 peak H_2S concentrations. Air Quality Figures 10 - 14 illustrate predicted impacts during limited mixing conditions. The lines on these figures, called "isopleths," indicate places where ambient H_2S concentrations are equivalent. Figures 10 and 12 present the concentrations which resulted when a tracer gas was released at 820 feet (SF_6) and at 320 feet ($CBrF_3$) above the ground, respectively. The 820-foot release should represent the expected plume height under normal operating conditions while the 320-foot release should simulate the expected plume height during stacking. Air Quality Figures 11 and 13 present the results of the Hybrid Model simulation, plume motion, and diffusion under tracer test conditions.

The equivalent worst-case H_2S impact observed during the tracer test (from SF_6 , the higher release height) was approximately 0.7 ppb** at Whispering Pines. Involved parties assume that worst-case concentrations occurring within two or three grid cells of receptor areas represent worst-case predicted model impacts. This is based on the observation that modeling results tend not to be exactly on target. Using pertinent data describing the meteorology which occurred during the tracer test day, the Hybrid Model simulated plume transport and diffusion. The model predicted a peak concentration of approximately 1.1 and 1.17 ppb (upper and lower release heights respectively) at the same general geographic location as observed during the tracer test.

*T.W. Tesche et al., Air Quality Analysis of the Proposed Occidental Geothermal Power Plant, Final Report, (SAI), March 31, 1981.

**The peak value on Air Quality Figure 10 is 0.071 ppb per pound H_2S emitted. Based on a 9.7 pounds H_2S /hour emission rate, the predicted H_2S impact is 0.69 ppb ($9.7 \text{ lbs } H_2S/\text{hr} \times 0.071 \text{ ppb/lbs } H_2S$) of H_2S .

Air Quality
Table 6
PEAK CONCENTRATIONS DUE TO OXY #1

Meteorological Condition	Receptor Areas	Tracer		1984 ^{3/}
		Test	Simulation	Simulation
Oxy #1 Impacts ^{1/}				
Limited Mixing	Anderson Springs, Whispering Pines, Collayomi Valley	0.69 ppb	1.1 ppb	1.8 ppb
Downwash	Lake County Anderson Springs	0.18 ppb	--	--
SMUDGE #1 Impacts ^{2/}				
Limited Mixing	Anderson Springs, Whispering Pines, Collayomi Valley	0.9 ppb	0.6 ppb	0.8 ppb

1/ Based on a 9.7 lbs/hr H₂S emission rate.

2/ Based on a 8.0 lbs/hr H₂S emission rate.

3/ Impacts only under limited mixing conditions were simulated for 1984 emissions at The Geysers.

OXY GEOTHERMAL #1

FIGURE 10: AIR QUALITY—Isopleths of Maximum Equivalent H₂S Based on Occidental Test 1 Limited Mixing (SF₆ Results)

OXY GEOTHERMAL #1

1600 to 1700 hours

Source: Oxy #1 AFC

FIGURE 11: AIR QUALITY-Equivalent H_2S Isopleths for Limited Mixing-820 feet (SF_6) Model Simulation (ppt)

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

FIGURE 12: AIR QUALITY—Isopleths of Maximum Equivalent H₂S at 1 lb/hr from CBrF₃

OXY GEOTHERMAL #1

FIGURE 13: AIR QUALITY-Equivalent H_2S Isopleths for Limited Mixing-320 feet($CBrF_3$) Model Simulation (ppt)

OXY GEOTHERMAL #1

(p) Between the Hours of 2000 and 2100

Source: Oxy #1 AFC

FIGURE 14: AIR QUALITY—Predicted 1984 Worst-Case H₂S Concentrations Due to OXY#1 Emissions (ppt)

The mountainous or "complex" terrain at The Geysers makes it extremely difficult to simulate plume motion in the atmosphere. Complexity notwithstanding, comparing the tracer test results with those of the modeling shows a promising degree of correlation.

Hybrid model simulations of other tracer tests resulted in predicted peak concentrations that differ from observed values by a factor of 1.5 to 3. Applying this to the peak value of 1.1 ppb (Air Quality Figure 11) results in a range of 1.6 ppb to 3.3 ppb.

In the SMUDGE #1 case, SMUD, SAI (the applicant's air quality consultant), and the CEC staff agreed that a reasonable estimate of the incremental impact from the SMUDGE #1 project in the Anderson Springs area was 2 ppb. The LCAPCO and NSCAPCO disagreed and concluded that it was likely that model results were underestimated. Based on a ratio of the SMUDGE #1 (8 pounds per hour) and Oxy #1 (9.7 pounds per hour) emission rates and air estimated SMUDGE #1 incremental impact of 2 ppb, the Oxy #1 incremental impact is 2.4 ppb ($9.7/8.0 \times 2.0 = 2.4$) in the Anderson Springs area. This assumes data obtained from the SMUDGE #1 analysis is also applicable to the Oxy #1 project.

In addition to the tracer tests and modeling studies, the parties selected an historical day from the SRI data base, during which elevated H_2S readings occurred in receptor areas. The parties selected July 28, 1976, and pertinent meteorological data from this day were input to the model. Air Quality Figure 14 illustrates the impacts predicted for emissions of 9.7 pounds per hour of H_2S from Oxy #1. The peak value predicted is 1.8 ppb H_2S in the Ford Flat/Anderson Springs area.

Considering the uncertainties involved with the approaches (established tracer test methodology and state-of-the-art modeling) used in these analyses, a reasonable estimate of the worst-case impact from Oxy #1 H_2S emissions (9.7 pounds per hour) is 2 to 3 ppb H_2S at sensitive receptor areas under limited mixing conditions. A conservative estimate in light of the uncertainties would be less than 5 ppb. The incremental impacts would be proportionally less for a lower emission rate.

This contribution, in and of itself, will not constitute a violation of the state ambient air quality standard for H_2S . However, the background or "cumulative" concentration from existing plants must be added to Oxy's incremental impact to determine if there will be violations of the standard in populated areas when Oxy #1 begins operation (see Cumulative Impacts--Air Quality for this analysis).

Downwash Incremental Impact

The results of the Oxy downwash tracer test are provided in the ES&S Report "Tracer Dispersion Test, Data and Analyses, Occidental 75 MW Geothermal Project, Lake County, California," May 15, 1981. The results indicate that the maximum incremental impact under downwash conditions would be at Lincoln Rock (see Air Quality Figure 15) and would be approximately 0.56 ppb H_2S (based on a 9.7 pounds per hour H_2S emission rate). The downwash impact from

FIGURE 15: AIR QUALITY—Isopleths of Maximum Equivalent H₂S at 1 lb/hr

the Oxy #1 project at Anderson Springs would be 0.18 ppb H_2S . Consequently, the impacts from the Oxy #1 project could be considered negligible under downwash.

MITIGATION MEASURES

As previously indicated, Occidental agreed to use the Stretford and Hydrogen Peroxide (with or without catalyst) processes to abate H_2S in the incoming stream. It can reasonably be expected that these controls could abate H_2S to the required levels. Based on recent cases before the CEC, it is also likely that the permitting authority would consider these controls in combination to be BACT.

Occidental also committed to use dual turbines and a turbine bypass system to mitigate stacking events. The turbine bypass system will route steam around the turbine(s) to the downstream abatement systems during unit outages. If only one turbine is out of operation, the remaining turbine could use the excess steam from the other turbine for power production. This dual turbine/turbine bypass design will reduce stacking and provide greater operational flexibility.

Reliability of the proposed abatement systems is critical to maintaining the required emission rate and to successful operation of the stacking controls. The CEC staff expects the turbine bypass mechanism to operate reliably. Reliability of the downstream controls, however, is critical to the operation of the bypass system.

PGandE, at a recent workshop on NSCAPCD-proposed rule changes, indicated that they are experiencing corrosion effects on stainless steel screens located downstream of the Hydrogen Peroxide process on Unit 15. LCAPCD indicates this may also be a problem on PGandE Unit 13. The extent and cause of the corrosion is not certain at this time, although PGandE attributes the corrosion to the chelating agent. If the problem proves to be significant, a possible solution could be to reduce the amount of chelating agent and ferrous catalyst being injected and increase the reaction time by increasing the length of piping or by installing a holding tank in the stream.

Other than the corrosion problems discussed above, there appears to be little that can go wrong with the Hydrogen Peroxide process that cannot be mitigated. The major components of the process are pumps, valves, pipes, and storage tanks. If the design provides for sufficient redundancy and capacity for the critical components (i.e., pumps and valves), the availability of the Hydrogen Peroxide process should be high.

Control of the input rate of hydrogen peroxide is critical to maintaining the control efficiency, because the inlet H_2S concentration can vary over a wide range in a short time. Currently there are not adequate H_2S condensate monitoring devices to provide automatic control of the input rate of hydrogen peroxide. PGandE and other utilities are currently pursuing development of continuous H_2S condensate monitors, primarily for compliance purposes. However, when adequate monitors are developed, they can be used to provide the

necessary feedback to control the hydrogen peroxide input rates, thus improving the reliability of the control process.

CEC staff expects the reliability of the Stretford process to be relatively good, based upon previous use of Stretford in the petroleum industry. PGandE indicated that they have experienced problems with sulfur clogging some lines. This problem can be overcome by redesigning the sulfur lines. If the design provides for sufficient redundancy and capacity for critical components, the Stretford process should obtain a high availability factor.

Drift eliminators will be installed on the cooling tower, which will limit the drift to 0.001 percent of the circulating water flow rate. This level of control is the current state-of-the-art. The use of this control measure will reduce particulates and some pollutants of concern to public health.

NOISE

SETTING

LEGAL REQUIREMENTS

Lake County

Lake County adopted a Noise Element to the County General Plan which establishes an acceptable ambient noise level for residential receptors of 55 dBA L_{dn} ,* from all sources. Lake County currently establishes noise limits by placing conditions in the use permit. The most recent permit (PGandE Unit 13) establishes a standard of 55 dBA L_{dn} at a residential receptor. A source standard is established in order to determine whether a violation of the use permit exists. At Unit 13, this source standard value was 75 dBA (L_{eq}) at 200 feet from the plant. The permit conditions exclude construction activities, such as the movement of heavy equipment. Well drilling and production testing are not exempt.

Lake County is currently considering a draft noise control ordinance. At this time, it is speculative as to when and in what final form Lake County might adopt the ordinance. However, the draft ordinance standards which would apply to this project are 55 dBA for daytime hours (7 a.m. - 10 p.m.) and 45 dBA for nighttime hours (10 p.m. - 7 a.m.) for residences and open space.

Sonoma County

Sonoma County adopted a Noise Element to the County General Plan which indicates that noise levels between 50 dBA and 60 dBA L_{dn} are acceptable for residential land uses; noise levels between 60 dBA and 70 dBA L_{dn} require noise mitigation for residential land uses; and noise levels greater than 70 dBA L_{dn} are unacceptable for residential land uses (Noise Element, Table 42). Although the noise element also states that the above standards should be used in evaluating all new land uses, Sonoma County currently sets noise levels for geothermal projects in the individual use permits. The most recent use permit (Geothermal Kinetics Resolution No. 58299) contains a standard for construction activities of 65 dBA day and 55 dBA night and for operation of 60 dBA day and 50 dBA night, as measured at a residence.

State

The applicable state regulations are the CAL/OSHA Occupational Noise Exposure Regulations, Title 8 CAC, Article 105, General Industrial Safety Orders, which apply primarily to on-site conditions. The Division of Occupational Safety and Health (DOSH) of the Department of Industrial Relations enforces the CAL/OSHA regulations. These regulations set a 90 dBA employee exposure limit for an 8-hour period and reduce the exposure time in half for each 5 dBA increase in the noise level above 90 dBA. There is no direct state regulation of off-site conditions.

*See glossary for definition of terms.

Federal

The EPA has identified an L_{dn} of 55 dBA as providing reasonable protection against community annoyance and activity interference due to noise (U.S. EPA, 1971). The Occupational Safety and Health Act of 1970 (29 CFR 1910 et seq.) establishes federal worker standards which are basically the same as the CAL/OSHA regulations identified above.

Environmental Description

The sensitive receptor nearest the proposed plant site is a residence off-road (survey point 5), approximately 9,130 feet west of the proposed site. See attached Noise Figure 1 for location of the proposed facility and sensitive receptor locations.

Ambient noise levels at the nearest residential receptor range between 70 dBA and 29 dBA.* Noise levels at other locations in the site vicinity were provided in PGandE Geysers Unit 18 AFC, Table 5.6-1 (see attached Noise Table 1; also see Noise Tables 2 and 3 for minimum levels measured at sensitive receptors). Noise levels in the site vicinity typically range between 25 dBA and 46 dBA with occasional peaks as high as 70 dBA. Noise sources in the site vicinity consist of the following: local and remote steam development activities, local traffic, wind, insect and wildlife activities, and human activities. Noise levels in the vicinity of a site are typical for a quiet rural environment (see attached Noise Table 4 from PGandE Geysers 16 NOI).

The nearest well pad to a sensitive receptor (i.e., Site 5, a single family residence) is approximately 1.5 miles away.

IMPACTS

The generally accepted criterion for determining the existence of a noise impact is audibility. To determine audibility, one must examine the background or ambient noise levels, the noise source's projected noise levels, and the tonal content of the noise. If a source's projected noise level is greater than or equal to the ambient noise level, it will probably be audible. A source whose tonal content is different than the existing ambient level will tend to be more audible than one whose content is similar to the existing ambient.

STEAM FIELD

Noise Table 5 shows the primary noise sources and levels associated with steam field development and operation. The noise levels shown include mitigation measures unless otherwise stated. Production testing, unmuffled well venting, and wellhead master valve changes are potentially significant noise sources in the vicinity of the well pad. These activities occur infrequently and can be conducted during daylight hours. Other sources will not be significant at the nearest receptor because of the remoteness of the site.

*These noise levels and other noise source and levels were provided in the AFC. These data were not independently verified by CEC staff. However, the methodology and equipment used and values obtained appear to be reasonable.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

LEGEND

- LEQ CONTOURS
- - - - - PORTION OF LEQ CONTOURS IN SHADOW ZONE
- ↑ ↑ SHADOW ZONE BOUNDARY; SHADOW ZONE IN DIRECTION OF ARROWS
- RADIALS CONNECTING SHADOW ZONE BOUNDARIES
- * RECEPTOR SITES

NOTE:

WORST CASE NOISE PREDICTION WHICH ASSUMES DIRECT LINE OF SIGHT AND ONLY HEMISPHERICAL SPREADING AND ATMOSPHERIC ABSORPTION. ACTUAL LEQ LEVELS WOULD BE LOWER THAN THOSE INDICATED BY THE CONTOURS.

FIGURE 1: NOISE-LEQ Contours for Construction Noise

Noise
Table 1

AMBIENT SOUND LEVELS IN dBA, RE. 20 MICROPASCAL, AT AND AROUND UNIT 18

<u>Date</u>	<u>Time</u>	<u>Point</u>	<u>Inst.</u>	<u>Meas.</u>	<u>Sample Duration</u>	<u>Range</u>	Sound Level, dBA, re 20 Micropascal						<u>Comments</u>
							L ₁	L ₁₀	L ₅₀	L ₉₀	L ₉₉	L _{eq}	
6/23/77	1400	1	A	Cont.	5 Min.	-	38.8	35.5	33.0	31.0	30.3	33.5	Natural Sounds, Fair Weather
10/25/77 to 10/26/77	1658 to 0758	2 (Site 18)	A	Cont.	15 Hrs.	-	43.3	36.8	31.8	29.8	28.8	34.4	Natural Sounds, Remote Steam Bleed to SE. Very calm - Quiet conditions, fair weather
10/26/77	0845 to 1345	2 (Site 18)	A	Cont.	5 Hrs.	-	46.3	38.0	33.0	27.3	25.8	37.7	Same as above
10/25/77	1705 to 1717	3 to 7	B	D.O.	-	32/40	-	-	-	-	-	-	Natural sounds, calm quiet conditions after working hours at Unit 13.

NOTES:

- Abbreviations: Inst. - Instrumentation; Meas. - Measurement, Cont. - Continuous; D.O. - Direct Observation
- Instrumentation (Inst.) Column

A (System A): 1" Electret-Condenser Microphone to Gen Rad 1558-BP Analyzer to Bruel & Kjaer 4426 Noise Level Analyzer.
Continuous Measurement System with Sample Rate of 1 Sample/Sec.

B (System B): 1" Electret-Condenser Microphone to Gen Rad 1933 Precision Sound Level Meter. Direct Observation
(D.O.) of Meter Scale Approximately 1 Min./Observation

Calibration of both Systems A & B above in Field with Gen Rad 1562-A Sound Level Calibrator

SOURCE: PG&E Unit 18 AFC

Noise
Table 2

EXISTING NOISE ENVIRONMENT DURING QUIET CONDITIONS
LOCATION 8 (dBA)

<u>Date & Time</u>	L_1	L_{10}	L_{50}	L_{90}	L_{99}	L_{eq}	<u>Comments</u>
Thursday	38	32	26	24	24	29	Noise
11/15/79							environment
2:40-2:45 pm							controlled by
							unidentifiable
							natural sounds
							and occasional
							jet and far-off
							aircraft

SOURCE: Oxy AFC

Noise
Table 3

ESTIMATED WORST CASE NOISE LEVELS
AND MINIMUM MEASURED BACKGROUND LEVELS

<u>Locations of Nearest Sensitive Receptors</u>		<u>Construction (Leq)</u>	<u>Operation (Leq)</u>	<u>Minimum Measured L99</u>
<u>Number</u>	<u>Description</u>			
1	Pine Grove, near Bottle Rock Road	22 dBA	10dBA	20dBA
2	Hobergs, overlooking Bottle Rock Road	19 dBA	7dBA	27dBA
3	Anderson Springs	24 dBA	14 dBA	34 dBA
4	Whispering Pines	25 dBA	15 dBA	32 dBA
5	Socrates Mine Road	32 dBA	24 dBA	38 dBA
6	Verdant Vales School, Castle Rock Springs	28 dBA	19 dBA	48*dBA
7	Mercuryville	15 dBA	3 dBA	26 dBA
8	Pine Flat Road	27 dBA	18 dBA	24 dBA

* Dominated by grading activities at location of Unit 16 site.

Noise

Table 4

A-WEIGHTED SOUND LEVELS, dBA, OF TYPICAL NOISES
IN VARIOUS ENVIRONMENTS*. REF. 2 X 10⁻³N/M²

Subjective Impression	dBA	Community** (Outdoor)	Home or Industry** (Indoor)
Uncomfortably Loud	130	Military Jet Aircraft Take-Off from Aircraft Carrier @ 50'. (130)	Oxygen Torch (121)
	120	Turbo-Fan Aircraft Take-Off @ 200'. (118)	Rock-N-Roll Band (108-114)
	110	Jet Fly Over @ 100'. (103)	Riveting Machine (110)
Very Loud	100	Power Mower (96) Boeing 737, DC-9 @ 6080' before landing (97)	Electric Furnance Area (100) Newspaper Press (97)
	90	Motorcycle @ 25'. (90) Car Wash @ 20'. (89) Diesel Truck, 40 mph @ 50'. (84)	Food Blender (88)
	80	High Urban Ambient Sound (80) Passenger Car, 65 mph @25'. (77)	Garbage Disposal (80) Living Room Music (76)
Moderately Loud	70	Freeway @ 50' from edge (76±6) Urban Shopping Center (60-70)	TV-Audio, Vacuum Cleaner (70) Elec. Typewriter @ 10'. (64) Dishwasher (Rinse) @ 10'. (60)
	60	Daytime Urban Residential (50-60)	Conversation @ 3'-5'. (60) Large Store (60)
	50	Large Transformers @ 100' (50) Daytime Suburban Residential (40-50)	Average Daytime Residence (40-50)
Quiet	40	Lower Limit Urban Ambient Sound (40) Farm in Valley (30-40)	
	30		Studio Speech (30) Quiet Bedroom at Night (20-30)
	20	Daytime Grand Canyon (North Rim) (20)	
Just Audible	10		
Threshold of Hearing	0		Threshold of Hearing for Youths - 1000-4000 Hz

* The noise sources and typical levels were taken from the following sources:

- Peterson, A. P. G. & Gross, E. E. Jr., "Handbook of Noise Measurement", General Radio Company 7th Edition 1972.
- Schultz, T. J., Bolt Beranek & Newman Inc., "Noise Assessment Guideline, Technical Background" Report No. TE/NA 172 prepared for U. S. Department of Housing and Urban Development.
- Wyle Laboratories, "Community Noise", Report No. NTID 300.3 prepared for U. S. Environmental Protection Agency, December 31, 1971.

** Numbers in parenthesis are A-weighted sound levels.

Source: Geysers 16 NOI

Noise

Table 5

NOISE LEVELS DUE TO GEOTHERMAL DEVELOPMENT AND OPERATION ACTIVITIES

Activity	Max. Noise Levels at (50') (15.2m) in dBA	Nearest Receptor ^a Projected Noise Levels at (7920') (2414m) in dBA
Construction of roads and drill pads	90 ^b	29-39 ^c
Construction of steam pipelines	90 ^b	29-39 ^c
Mud drilling	85 ^d	24-34 ^c
Air drilling (cyclonic muffler)	88 ^d	29-39 ^c
Air drilling in steam (cyclonic muffler)	90 ^d	29-39 ^c
Well clean-out (cyclonic muffler)	90 ^d	29-39 ^c
Production testing (cyclonic muffler (portable test muffler)	90 ^d 100 ^d	29-39 ^c 39-49 ^c
Shut-in well venting	75 ^d	24
Normal Field Operations	40-70 ^d	19
Steam venting at generating unit (rock-filled muffler)	70 ^e	19
Starting steam transmission thru pipelines (unmuffled well venting)	120 ^b	59-69 ^c
Changing wellhead master valves (unmuffled well venting)	110 ^b	49-59 ^c

a. Estimated projected levels made by CEC

b. Estimated from noise measurements.

c. Higher noise levels are based on worst case weather conditions; lower levels are based on normal attenuation of noise.

d. Based upon measurements by P. Leitner.

e. Based upon measurements by PGandE and Union Oil.

Source: Nielson, 1977; Castle Rock Springs Geothermal Steam Area EIR, 1975; Geothermal Pipeline System Unit 16 Castle Rock Springs Area EIR, 1979.

PLANT CONSTRUCTION

The highest construction noise levels range between 75 dBA and 95 dBA at 50 feet (see Noise Table 6). The higher noise levels can be attributed to large earth moving equipment and blasting. Measurements made at Geysers Unit 13, with 9 pieces of equipment operating, showed an average L_{eq} level of 76 dBA at about 360 feet from the center of the construction site (PGandE Geysers Unit 18, page 5-85). The CEC staff expects the noise levels during site preparation, projected to the nearest sensitive receptor (survey point 5) in Lake County, to range from 30 - 40 dBA L_{eq} (see Noise Figure 1 for estimated construction noise contours). Projected construction noise may occasionally be barely audible at the nearest receptor in Lake County when the construction noise level is in the high range and ambient levels are low. Since construction occurs only during daylight hours, barring unforeseen circumstances, the potential noise impact would be insignificant. Construction noise levels would meet the standards of Lake and Sonoma counties.

CONSTRUCTION TRAFFIC

Noise Table 7 shows the construction traffic noise estimates. Based on these levels, the CEC staff would expect communities or single residences along the access routes to be exposed to intermittent noise levels which would exceed the nighttime standard of the Lake County draft noise ordinance. Construction traffic should be limited to daylight hours.

PLANT OPERATION

Occidental estimated the operational noise levels projected to receptors in the vicinity of the site. These are shown in Noise Figure 2 and in Noise Table 3. The estimated noise level projected to the nearest receptor is 24 dBA L_{eq} . Actual projected noise levels may be less, due to ground effects and possible barrier effects. In any case, this noise level will comply with the existing and proposed Lake County standards. Operational noise will not be audible at the nearest receptor.

NOISE TONAL IMPACTS

In the PGandE Geysers Unit 17 AFC, PGandE provided (Appendix G, Figures 9.4-1 through 9.4-3) one-third octave band noise frequency spectra from operating Geysers units. Occidental agrees that these frequency spectra are representative of the noise expected from the proposed Oxy #1 facility. While certain tonalities would be discernable in the immediate vicinity of the site, it is the CEC staff's opinion that the tonalities would not be discernable at any of the receptors in the site vicinity due to the low projected noise levels to the receptor. This means that the noise resulting from Occidental geothermal development will not be noticeable at the nearest residence to the plant.

CAL/OSHA REQUIREMENTS

Occidental stated (AFC, pages 1-23 and 1-24) that they will take the following steps to ensure compliance with CAL/OSHA noise regulations:

1. Any unavoidably high noise areas will be posted with signs.

Noise
Table 6

PROJECTED CONSTRUCTION EQUIPMENT USE

<u>Item</u>	<u>Number Used</u>	<u>Time Use Factor (%)</u>	Range of Measured dBA <u>Maximum</u> (at 50 ft)	<u>Base dBA Used for Estimating</u>
<u>SITE PREPARATION</u>				
Bulldozer	2	75	77-90	89
Dump Truck	2	50	84-87	86
Loader	1	75	77-90	89
Compactor	1	75	75-82	81
Water Truck	1	50	81-94	83
Scraper	2	75	88-91	90
<u>PLANT ERECTION</u>				
Lift Crane	2	70	80-85	84
Backhoe	1	75	86-90	89
Batch Plant	1	40	83	83
Transit Mixer	1	50	84-87	86
Concrete Pump	1	50	74-84	83
Welder	2	80	73	73
Air Compressor	2	75	76-89	86
Lowboy	1	10	84-87	86
Light and Medium Trucks	3	50	81-84	83
Water Truck	1	50	81-84	83
<u>TRANSMISSION LINE CONSTRUCTION</u>				
Crawler Tractor	2	75	85-90	89
Grader	1	75	86-89	88
Hauling Trucks	2	75	86-88	87
Mobile Crane	1	70	80-85	84
Air Compressor	1	75	76-89	88
Concrete Mixer Trucks	2	50	84-87	86
Light Trucks	2	50	81-84	83
Medium Trucks	2	50	84-87	86
Chain Saw	1	25	72-88	87

Noise
Table 7

ESTIMATED CONSTRUCTION TRAFFIC NOISE

<u>Assumed Condition</u>	<u>Distance (ft)</u>	<u>Leq (dBA)*</u>
50% of traffic in each direction (65 autos, 5 heavy trucks)	200	49
Same as above	2,000	35
90% of traffic using one access (117 autos, 9 heavy trucks)	200	51
Same as above	2,000	37
10% of traffic using one access (13 autos, 1 heavy truck)	200	42
Same as above	2,000	28

*Assumes a long, straight road on a 7 percent grade, the line of sight from vehicle to receiver, and "soft" ground between vehicle and receiver.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

NOTE:

WORST CASE NOISE PREDICTION WHICH ASSUMES DIRECT LINE OF SIGHT AND ONLY HEMISPHERICAL SPREADING AND ATMOSPHERIC ABSORPTION. ACTUAL LEG LEVELS WOULD BE LOWER THAN THOSE INDICATED BY THE CONTOURS.

LEGEND

- LEQ CONTOURS
- - - PORTION OF LEQ CONTOURS IN SHADOW ZONE
- ↑↑ SHADOW ZONE BOUNDARY; SHADOW ZONE IN DIRECTION OF ARROWS
- RADIALS CONNECTING SHADOW ZONE BOUNDARIES
- * RECEPTOR SITES

FIGURE 2: NOISE-LEG Contours for Operational Noise

2. As necessary, personal hearing protectors will be supplied and their use enforced during both the construction and operational periods.
3. The hearing of employees routinely subjected to high noise levels will be periodically checked.

If these measures are implemented, the CEC staff will conclude that Occidental will adequately meet the hearing conservation requirements of CAL/OSHA.

MITIGATION MEASURES

Occidental identified (AFC, pages 1-23 and 1-24) the following noise mitigation measures to be applied to the proposed facility:

1. Mechanical equipment will be purchased on the basis of a procurement-specific action that will encourage manufacturers to supply reduced-noise motors, pumps, valves, and other components;
2. Noisy steam-handling equipment, steam piping, and steam ejector housings will be insulated with materials possessing good acoustic and thermal properties;
3. Waste steam will be routed when necessary through an effective muffling system;
4. A low-noise office enclosure for the operators will be provided inside the turbine building;
5. The turbine building walls and roof will reduce the propagation of noise to the outside environment; and
6. Any excessively noisy ancillary equipment will be silenced as feasible.

In addition, Occidental agrees to incorporate the following steps when implementing the above mitigation measures:

- a. Except for the turbine generator sets, which shall be specified for 90 dBA, require equipment manufacturers, where applicable, to supply equipment with a maximum sound level of 85 dBA at 3 feet. If the manufacturer cannot meet this specification, the Applicant shall undertake appropriate mitigation measures to conform with OSHA/DOSH standards,
- b. Route the steam drain lines from the turbine to the condenser so that steam will not be discharged into the atmosphere during unit start-ups, and
- c. Utilize to the maximum extent feasible a rock muffler or an equivalent noise reducer to mitigate noise during unit outages.

Occidental should also limit construction traffic to daytime hours.

WASTE MANAGEMENT

SETTING

Construction and operation of a geothermal power plant produces a number of potentially hazardous liquid and solid wastes. These wastes include contents of steam well drilling sumps, construction wastes, condensate from the spent geothermal steam, by-products from the H₂S abatement system(s), and sanitary wastes. Mitigation of potential health hazards from toxic waste disposal is assured through a series of health and safety oriented regulations developed by the California Department of Health, the Environmental Protection Agency, and the Water Quality Control Board.

Currently, PGandE operates all power plants at The Geysers. PGandE hauls all hazardous wastes produced by its operations to Geothermal, Inc.'s Class II-1 hazardous waste disposal site near Middletown in Lake County. Since Occidental Geothermal, Inc., proposes a similar operation, the CEC staff assumes that the impacts of their operation will be similar to PGandE's.

DRILLING WASTES

Drilling wastes consist of drilling mud used in developing the geothermal resource and the borings produced by such drilling. The drilling mud can contain chemicals added to improve drilling performance. Chromium compounds which are toxic to humans and are included in the California Department of Health Services list of hazardous wastes (DOHS, 1981) have been used in the past (Gennis, 1977).

CONSTRUCTION WASTES

Construction wastes will include cleared vegetation, miscellaneous debris, oily discharge and residues, unsalvageable wooden shipping crates and skids, cardboard boxes, lumber scraps, concrete wastes, paper, and plastic wrapping.

OPERATIONAL WASTES

Potentially toxic wastes from the geothermal power generation process include the excess condensate, water from the cooling tower basin, maintenance wastes such as used oil and cleaning fluids and fluid wastes from air pollution control equipment.

SANITARY WASTES

Sanitary wastes consist of those produced in sanitary facilities used by on-site workers. During normal operating conditions, a staff of two or three workers could produce 200 gallons of sewage daily.

POTENTIAL DISPOSAL SITES

Wastes produced by geothermal power plant operations must be disposed of at sites approved by the responsible regulatory agencies: the Regional Water Quality Control Board, the Department of Health Services, and the local agencies.

These agencies allow geothermal waste disposal at any Class I disposal site or Class II-1 disposal sites that have been approved specifically for geothermal wastes. For environmental protection, all official disposal sites are designed according to constraints established by the regulating agencies: the California Department of Health Services and the Regional Water Quality Control Board. Class I disposal sites are separated from usable groundwater by natural geologic formations and are not subject to flooding. Class II-1 disposal sites are separated from usable groundwater by artificial means, usually must be monitored, and are protected from flooding by a storm or flood having a predicted frequency of once in 100 years.

Geothermal, Inc., operates a Class II-1 disposal site near Middletown in Lake County, about six miles from the proposed project area. This operator has a permit to accept all wastes produced by the geothermal power plants in The Geysers KGRA (Central Valley RWQCB, 1979).

The IT Corporation operates a Class II-I disposal site near Kelseyville in Lake County, about 17 miles from the proposed project area. The site operator is fully licensed for disposal of all wastes produced by the existing power plants in the KGRA. Based upon the current rate of waste production from Geysers Units 1 - 12, the current site has a design life of 30 years. (Posson, 1981).

IT Corporation also operates a Class I disposal site near the City of Martinez in Contra Costa County, about 75 miles from the proposed project area. This site is licensed to accept wastes of the type produced in geothermal power plant operations.

IMPACTS

Hazardous wastes are of special concern because of their potential for causing significant adverse impacts on public health and the environment. The California Department of Health Services considers geothermal drilling wastes, cooling tower sludge, and the elemental sulfur produced as a by-product from the Stretford process, as hazardous wastes (DOHS, 1979). Other hazardous wastes include oils, thinners, and solvents.

DRILLING WASTES

See Public Health Impacts.

CONSTRUCTION WASTES

Although the total production of construction waste is not known, the Occidental project will produce 20 to 30 cubic yards of waste per week during times of peak construction activity. During a typical 32-month construction period, PGandE's projects have produced as much as 3,500 cubic yards of construction waste (Geysers Unit 18 Final EIR, Appendix C). If such wastes were stored on site, there would be significant potential aesthetic, biological, and water quality impacts; however, Occidental proposes to use drop boxes each with a 20 cubic yard capacity, which will be removed weekly.

OPERATIONAL WASTES

Occidental's proposed Stretford system would produce approximately 13 cubic yards of sulfur and used process solution per week. In addition, a secondary

H₂S abatement system will be required. This system will add a chelated iron catalyst and hydrogen peroxide to the steam condensate before it passes through the cooling tower. The hydrogen peroxide will oxidize the dissolved hydrogen sulfates to elemental sulfur. Side reactions with the catalyst may result in the production of iron sulfide precipitants. The elemental sulfur and iron sulfide solids from the secondary abatement system are expected to amount to less than 3.5 cubic yards of sludge per year. Unless properly disposed of, these operational wastes might cause significant adverse environmental impacts on water quality, public health, and vegetation.

SANITARY WASTES

Exposure of people to sanitary wastes through inadequate disposal can result in nuisance odors and the spread of communicable diseases.

MITIGATION MEASURES

HAZARDOUS WASTES

There are a number of federal, state, and local laws which regulate the safe handling of toxic waste materials. Compliance with the following requirements will reduce the risk of impacts from hazardous wastes to an acceptable level.

Federal

- o Hazardous Materials Transportation Act, Public Law 93-633, 49 United States Code Section 1801 et seq.--The regulations adopted pursuant to this act are codified in Title 49 of the Code of Federal Regulations, Parts 100 through 199. These regulations provide authority to the Secretary of Transportation to guard against risks to life and property which are inherent in the transportation of hazardous materials.
- o Resource Conservation and Recovery Act of 1976 (RCRA), Public Law 94-580, 42 United States Code Section 6901 et seq.--The regulations adopted pursuant to this act are codified in Title 40 of the Code of Federal Regulations. Although not all final RCRA regulations have been promulgated, the Environmental Protection Agency has authorized California's hazardous waste management program to be operated in lieu of the RCRA program except for issuing new permits for new treatment, storage, and disposal facilities. Therefore, the California Health and Safety Code cited below regulates hazardous waste management practices in California. California's permit program is expected to receive authorization soon (Blais, 1981).

California

- o California Water Code, Division 7.5, "Transportation and Disposal of Waste"--Each Regional Water Quality Control Board (RWQCB) may approve sites suitable for the disposal of different kinds of wastes. Section 13360 allows the RWQCB to specify the design, location, or type of construction of evaporation ponds and solid waste disposal sites. California Administrative Code, Title 23, Chapter 3, Subchapter 15, "Waste Disposal to Land," contains the regulations implementing these statutes.

- o California Health and Safety Code, Division 14, Chapter 6.5, "Hazardous Waste Control"--Allows the Department of Health Services to specify standards and procedures for determining the appropriate classification of wastes and, if hazardous, the proper disposal and transportation methods. California Administrative Code, Title 22, Division 4, Chapter 30, contains the regulations implementing those statutes.
- o California Governmental Code, Title 7.3, "Solid Waste Management and Resource Recovery"--Allows the Solid Waste Management Board to license disposal sites or to give the permitting authority to counties which have an approved program. California Administrative Code, Title 4, Division 7, Chapter 3, "Minimum Standards for Solid Waste Handling and Disposal," contains the regulations implementing these statutes.
- o "California Assessment Manual for Hazardous Wastes," published by the Department of Health Services--Gives DOHS guidelines for determining the classification of wastes.
- o "Waste Discharge Requirements for Non-Sewerable Waste Disposal to Land," published by the State Water Resources Control Board--Provides disposal site design and operational information.
- o California Vehicle Code, Sections 2402 and 34501 and the regulations adopted pursuant to it contained in Title 13 of the California Administrative Code, Article 1.3, "Hazardous Materials Definitions," and Article 1.5, "Hazardous Materials Transportation"--These regulations prescribe requirements for shipping hazardous materials by highway. They are enforced by the California Highway Patrol.

Local

- o Lake County Code, Chapter 9, "Health and Sanitation," Article I. This code prohibits unlawful waste disposal in Lake County.

Limited quantities of potentially toxic or hazardous wastes may be stored on site for a limited period of time. Storage facilities must be maintained in conformance with regulations of the California Department of Health Services and the Regional Water Quality Control Boards.

Transportation of these wastes is also regulated by the Department of Health Services, Hazardous Materials Management Section (DOHS). Hazardous wastes being removed from the site for disposal must be carried in trucks by registered haulers who must comply with applicable sections of the California Health and Safety Code and pursuant to DOHS regulations.

By law (California Health and Safety Code) the producer of hazardous wastes is responsible for their disposal even after they have been delivered to the hauler. In the event of a spill during handling or transport of these wastes, protective service agencies, such as the county sheriff, highway patrol, highway department, and fire department, generally respond to assist in needed abatement, cleanup, or other protective measures. The Department of Health Services and Regional Water Quality Control Boards may provide consulting services if requested.

Hazardous wastes must be disposed at approved Class I or Class II-1 sites. Available sites are located in Martinez, Middletown, or Kelseyville. Occidental or its contractor(s) should determine whether the proposed disposal site(s) has adequate capacity for estimated wastes produced during the lifetime of the proposed project, and if not, Occidental should select an alternate disposal site. Occidental has not yet contracted with any waste disposal sites.

The California Department of Health Services considers elemental sulfur produced as a by-product of the Stretford process hazardous. As such, it is subject to the regulations shown above; however, as a nearly pure sulfur cake, this by-product is also saleable, and therefore, Occidental may opt to sell this waste to industry.

DRILLING WASTES

By order of the Regional Water Quality Control Boards (CVRWQCB Order No. 78-184 and NCRWQCB Order No. 78-17), after the liquid portion of the contents of drilling sumps evaporates, the well field operator should analyze the solid portion. If it is hazardous, it will be disposed of as described in the Mitigation Measures for Hazardous Wastes subsection above. If it is not, it will be covered with earth, and the surface will be revegetated. Compliance with these measures and those described in the Water Quality section of the EIR will render drilling waste impacts insignificant.

CONSTRUCTION WASTES

Geothermal operators may dispose of cleared vegetation and miscellaneous debris on site or at an approved disposal site. Unregistered haulers can transport wastes which are not hazardous and dispose of them in any site which has been approved by the Regional Water Quality Control Board and responsible local agencies. This procedure will render impacts of such wastes insignificant.

OPERATIONAL WASTES

Underground Injection

Other geothermal units dispose of potentially toxic wastes, including steam condensate and liquid abatement equipment wastes, by injecting them into the steam reservoir through nearby dry or under productive wells. Tests of the hydrogen sulfide abatement system(s) currently in progress at PGandE's Unit 15 also include an investigation into the toxicity of the wastes produced by the abatement system(s).

Although no studies have determined the effects of injection of any of these geothermal wastes, no adverse effects are anticipated by either RWQCB or CEC staff because the reservoir lies far beneath any groundwater aquifers where natural barriers (tight and clay-like soils) and deep well casings separate it from these aquifers (CEC-SRI, 1977; Holman, 1978).

SANITARY WASTES

Sanitary wastes at the Occidental site will be of limited volume, but they cannot be disposed of on site because the slope and soils of the proposed site do not allow for construction of an adequate leachfield disposal system.

The responsible regulatory agencies (Regional Water Quality Control Boards and Department of Health Services) indicate that injection of sanitary liquid wastes back into the steam reservoir is an acceptable practice (Ed Crawford, CVRWQCB, 1979). If injected into the steam reservoir, any pathogens in this waste would be killed by the intense heat and pressure of the steam reservoir. This mitigation will render this impact insignificant. Geothermal operators, however, must dispose of solids off site.

HEALTH

SETTING

Existing levels of air and water pollutants and the human population which could experience adverse health effects constitute the two aspects of the environmental setting for the proposed facility which relate to public health.

EXISTING POLLUTANT LEVELS--AIR

The Air Quality Setting section discusses existing ambient air concentrations of regulated pollutants, including hydrogen sulfide, total suspended particulates, sulfur dioxide, and sulfates, in the project site area.

Ambient air concentrations of nonregulated pollutants, including radon-222, mercury, arsenic, ammonia, boron, silica, benzene, anthraquinone disulfonic acid, asbestos, and silica, have not been recently measured in the immediate project vicinity or in areas which could be impacted by the plant. However, limited measurements in The Geysers KGRA and measurements in rural areas elsewhere in the country suggest concentrations expected in The Geysers KGRA (see Health Impacts, Table 4). The following paragraphs summarize available monitoring results from The Geysers KGRA.

Lawrence Livermore Laboratory measured radon-222 in the atmosphere at The Geysers KGRA for PGandE during 1975-77 when only 11 geothermal power plant units were operational (Anspaugh, 1978). The highest recorded radon-222 concentrations in air were 0.5 picocuries per liter (pCi/l)* at Units 1 and 2 and 1.4 pCi/l at the SRI Station 7 (Sawmill Flat). These peak values fall below the California emission limitation for radon-222 of 3 pCi/l (annual average) above background in uncontrolled areas.

Ambient air concentrations of mercury have not been monitored in populated areas near The Geysers KGRA. Two studies of mercury concentrations in ambient air in unpopulated areas within The Geysers KGRA report concentrations ranging from less than 0.001 ug/m³ to 0.018 ug/m³ (Robertson, 1977) and from 0.005 ug/m³ to 0.400 ug/m³ (Jepsen, 1973). Mercury mining was very common in the area at one time; thus, abandoned mercury mines and tailings may contribute significant amounts of mercury to ambient air levels.

PGandE reports that in 1977 ambient air arsenic concentrations at Unit 11 ranged from less than 0.010 ug/m³ to 0.044 ug/m³ (PGandE, 1979). Ambient air concentrations of boron in the atmosphere have not been measured at this time.

Research reveals relatively little monitoring of ambient air concentrations of ammonia at The Geysers KGRA. Periodic monitoring during 1976 and 1977 at a number of locations in The Geysers KGRA recorded one hour average ammonia concentrations ranging from 0 to 0.263 parts per million (ppm) (DWR, 1978).

*Picocurie = 10⁻¹² curie. A curie is a unit of radioactivity.

Ambient air concentrations or steam concentrations of asbestos have not been measured in The Geysers KGRA (Robertson, 1980; Wesolowski, 1980; CEC, 1980a). Casings in the upper levels of geothermal wells minimize contact between steam and asbestos-containing serpentine rock formations. Existing asbestos levels in the ambient air of The Geysers KGRA are probably too low to present a significant health hazard, due to typically small asbestos content (roughly 1 percent) in California serpentine rock.

Appendix B-1 describes the potential effects of geothermal air pollutants on human health.

EXISTING POLLUTANT LEVELS--WATER

The Water Quality Setting section of the EIR describes existing water quality and beneficial uses of surface water in the project area.

Week (1978) measured high concentrations of mercury in fish at Clear Lake, not far from The Geysers KGRA. Although the mercury content in most fish tested was below the recommended safe level of 1.0 ppm in edible fish flesh, a small number of the fish sampled exceeded this value. Such high levels are more likely caused by sources other than mercury emissions from geothermal power plants at The Geysers KGRA, such as abandoned mercury mines and tailings; yet, by inference, residents of this area may carry a significant burden of body mercury already. Any addition of mercury to the environment would increase this burden.

Appendix B-2 describes the potential effects of water pollutants on human health.

EXISTING HUMAN POPULATION IN THE VICINITY OF THE PROPOSED SITE

PGandE reported that in January 1977, 3,737 residents lived within 10 miles of Cobb Mountain, as shown in Table 1 (PGandE, 1978b). This figure includes residents of communities near the project site, but it does not include seasonal residents in the area, which may triple the population during summer months (Ecoview, 1978). Table 1 gives the approximate age distribution for these people. The Noise and Land Use Setting sections of the EIR discuss human receptor sites nearest the proposed site.

Data in Table 1 indicate that approximately 22 percent of the population in that area could be classified as sensitive to pollutants due to age (e.g., the very young and the elderly).

No reported studies describe existing public health status in The Geysers. No reported cases of adverse public health effects clearly link the cause to pollutants from The Geysers power plants, although some residents of Lake County report health effects which they attribute to emissions from geothermal operations (Grew, 1978; Madill, 1978). A survey of 142 Cobb Valley residents reported that 72 percent of the respondents disagreed with the statement that geothermal development would have no odor impacts (Vollintine and Weres, 1976).

TABLE 1

POPULATION DISTRIBUTION IN THE GEYSERS KGRA

Age Group*	Area		
	Within 7 Miles of Units 5 & 6	Within 10 Miles of Cobb Mountain	Within 30 Miles of Units 5 & 6
0-5	182 (10.5%)	322 (8.6%)	14,487 (8.6%)
6-17	439 (25.3%)	888 (23.8%)	36,342 (22.1%)
18-34	335 (19.3%)	685 (18.3%)	34,715 (21.1%)
35-64	586 (33.8%)	1,321 (35.3%)	53,999 (32.8%)
65+	194 (11.2%)	521 (13.9%)	25,188 (15.3%)
Total Population	1,735	3,737	164,731
Total Area	154 mi ²	314 mi ²	2,827 mi ²
Population density (persons/mi ²)	11.3	11.9	58.3

*January 1977 ages

Source: PGandE, 1978b.

IMPACTS

IMPACTS RELATED TO AIR POLLUTANTS

Introduction

The potential for health impacts from the project's air pollutant emissions depends on the concentrations of pollutants to which people would be exposed, the duration of exposure, and the toxicity of the pollutants. The project will add to existing ambient or background concentrations of hydrogen sulfide, radon-222, ammonia, suspended particulates, mercury, arsenic, boron, anthraquinone disulfonic acid, and vanadium in nearby areas. In addition, project emissions may increase airborne levels of sulfur dioxide, sulfates, asbestos, silica, and benzene.

The public health analyses and conclusions contained in this document are based on the air quality analyses conducted by Occidental Geothermal, Inc. (Oxy) and CEC staff, Oxy's responses to data requests from CEC staff, and independent CEC staff analysis. A list of assumptions used in this analysis is found in Appendix C.

Table 2 lists ambient air quality standards for regulated pollutants.

Table 3 lists values for assessing potential public health impacts from non-regulated pollutants in ambient air. Varying methodologies and criteria for determining these values result in divergent values (see Appendix C for a description of the types of values in Table 3). While neither CEC nor other state or federal agencies have adopted any of these suggested levels as standards, CEC staff includes these values, along with other values in Table 3, for use as a guide for determining which pollutants are not likely to pose a health hazard and which pollutants might require a more in-depth analysis and monitoring.

Appendix B-1 describes the potential effects of geothermal air pollutants on human health.

Regulated Pollutants

Hydrogen Sulfide (H₂S)

The California Ambient Air Quality Standard (CAAQS) for H₂S is 0.03 ppm (1 hour average). Although public health protection was considered, California Air Resources Board (CARB, 1970) based this value on the average H₂S odor threshold obtained in a study conducted by the California Department of Public Health. In that study, H₂S odor thresholds for 16 individuals ranged from 0.012 to 0.069 ppm; the geometric mean value was 0.029 ppm H₂S. A more recent report, prepared by Lawrence Berkeley Laboratories, states that if the standard is to be based on known odor threshold, "then the standard should be lowered by a factor of three to five to the more recently accepted value for the odor threshold" (Case, 1977). The California Department of Health Services (CDHS, 1981) recently reviewed the current standard for the Air Resources Board and recommended leaving the standard unchanged (Perry, 1980).

HEALTH TABLE 2
 AMBIENT AIR QUALITY STANDARDS

<u>Pollutant</u>	<u>Averaging Time</u>	<u>California Standard</u>	<u>Primary Federal Standard</u>
Carbon Monoxide	12 hours	10 ppm(11 mg/m ³)	-
	8 hours	-	10 mg/m ³ (9 ppm)
	1 hour	40 ppm(46 mg/m ³)	40 mg/m ³ (35 ppm)
Hydrogen Sulfide	1 hour	0.03 ppm(4 mg/m ³)	-
Non-Methane Hydrocarbons	3 hours	-	160 ug/m ³ (0.240 ppm)
Lead	30 day	1.5 ug/m ³	-
Nitrogen Dioxide	Annual Average	-	100 ug/m ³ (0.0500 ppm)
	1 hour	0.25 ppm(2.47 mg/m ³)	-
Oxidant (Ozone)	1 hour	0.10 ppm(0.20 mg/m ³)	240 ug/m ³ (0.120 ppm)
Sulfur Dioxide	Annual Average	-	80 ug/m ³ (0.03 ppm)
	24 hours	0.05 ppm(131 ug/m ³)*	365 ug/m ³
	1 hour	0.5 ppm(1310 ug/m ³)	-
Sulfates	24 hours	25 ug/m ³	-
Suspended Particu- late Matter	Annual Geo- metric Mean	60 ug/m ³	75 ug/m ³
	24 hours	100 ug/m ³	160 ug/m ³
Radon-222	Annual Average	3 pCi/l** ***	3 pCi/l** *** 1 pCi/l ****

* When standards for total suspended particulates of oxidant are being exceeded.

** Above natural background, at point of release to the environment, in uncontrolled areas.

*** Secondary standards for radon-222 itself.

**** The same conditions as the other radon standards, but radon-222 in combination with its short lived daughters is considered.

HEALTH TABLE 3

SUGGESTED LEVELS FOR NONREGULATED
POLLUTANTS IN AMBIENT AIR*

<u>Pollutant</u>	<u>Type of Value</u> ***	<u>Source</u>	<u>Concentration</u>	<u>Averaging Time</u>
Ammonia	California Occupational Standard	Cal/OSHA	25 ppm	8 hours
	Suggested Ambient Level Goal	EPA, 1977	0.06 ppm	annual average**
	Foreign Ambient Air Quality Standards	Russia and East European Countries	0.14-0.71 ppm	24 hours
Arsenic	Suggested Occupational Standard	NIOSH	2.0 ug/m ³	15 minutes
	Threshold Limit Value	ACGIH, 1980	50 ug/m ³	8 hours
	Presumed Safe Level	Wilcox, 1973	5.9 ug/m ³	24 hours
	Suggested Ambient Level Goal	EPA, 1977	0.005 ug/m ³	annual average**
Boron	Presumed Safe Level	Wilcox, 1973	50 ug/m ³	24 hours
	Suggested Ambient Level Goal	EPA, 1977	7.4 ug/m ³	annual average**
	California Occupational Standard	Cal/OSHA	10 mg/m ³ boron oxide	8 hours
Mercury	Presumed Safe Level	Wilcox, 1973	0.8 ug/m ³	24 hours
	Suggested Ambient Level Goal(based on toxicity)	EPA, 1977	0.1 ug/m ³	annual average**
	Suggested Ambient Level Goal(based on carcinogenic potential)	EPA, 1977	0.01 ug/m ³	annual average**
	California Occupational Standard	Cal/OSHA	50 ug/m ³	8 hours

Table 3 (continued)

<u>Pollutant</u>	<u>Type of Value</u>	<u>Source</u>	<u>Concentration</u>	<u>Averaging Time</u>
Vanadium	Presumed Safe Level	Wilcox, 1973	6.8 $\mu\text{g}/\text{m}^3$	24 hours
	Suggested Ambient Level Goal	EPA, 1977	1.2 $\mu\text{g}/\text{m}^3$	annual average*
	Threshold Limit Value	ACGIH, 1980	0.5 mg/m^3 (dust) 0.05 mg/m^3 (fume)	8 hours
	California Occupational Standard	Cal/OSHA	0.5 mg/m^3 (dust) 0.1 mg/m^3 (mist)	8 hours
ADA (anthraquinone disulfonic acid)	Suggested Ambient Level Goal	EPA, 1977 Supplement 2	260 $\mu\text{g}/\text{m}^3$	annual average*
Hydrogen Peroxide	Threshold Limit Value	ACGIH, 1980	1 ppm	8 hours
	California Occupational Standard	Cal/OSHA	1 ppm	8 hours
Iron	Threshold Limit Value	ACGIH, 1980	10.0 mg/m^3 (iron oxide fumes) 1.0 mg/m^3 (iron salts) 0.08 mg/m^3 (iron penta-carbonyl)	8 hours
	California Occupational Standard	Cal/OSHA	10.0 mg/m^3	8 hours
Copper	Suggested Ambient Goal	EPA, 1977	0.5 $\mu\text{g}/\text{m}^3$	annual average*
	Threshold Limit Value	ACGIH, 1980	0.2 mg/m^3 (metallic copper fume)	8 hours
			1 mg/m^3 (dusts and mists)	

Table 3 (continued)

<u>Pollutant</u>	<u>Type of Value</u>	<u>Source</u>	<u>Concentration</u>	<u>Averaging Time</u>
Benzene	Threshold Limit Value	ACGIH, 1980	30 mg/m ³ (10 ppm)	8 hours
	Emergency Temporary Occupational Standard	U.S. Labor Department (EPA, 1977)	3 mg/m ³ (1 ppm)	8 hours
	California Occupational Standard	Cal/OSHA	10 ppm	8 hours
Silica	California Occupational Standard	Cal/OSHA	10 mg/m ³ 1% SiO ₂ +2 (respirable)	8 hours
	Suggested Occupational Standard	NIOSH	50 ug/m ³	8 hours

* See Introduction for a discussion of the validity of these values.

** Although an averaging time for Suggested Ambient Level Goals is not stated within the document, (EPA, 1977) the authors have indicated that these goals are most applicable to annual average concentrations.

Abbreviations: Cal/OSHA - California Occupational Safety and Health Administration;
NIOSH - National Institute for Occupational Safety and Health;
ACGIH - American Conference of Governmental and Industrial Hygienists;
EPA - U.S. Environmental Protection Agency

Compliance with the CAAQS of 0.03 ppm H₂S appears to protect public health in that adverse health effects have not been reported from exposure at or below this level (see Appendix B-1). However, even at this concentration, the nuisance odor of H₂S would be noticeable to at least some of the general public (Miner, 1969).

Oxy estimates the H₂S content in the untreated steam for this project to be 90 ppm $\pm$ 30 ppm, based upon test results from 2 wells (AFC, Table 1.2-3). Estimates based on a steam flow rate of 1.6 million lb/hr (AFC, Figure 1.4-21) indicate total unabated H₂S emissions at a maximum of 193 lbs/hr (AFC, p. 1-20).

CEC staff determined that with hydrogen sulfide abatement equipment the project will comply with emission regulations and limitations (see Air Quality Impacts section). However, violations of the CAAQS for H₂S already occur in The Geysers KGRA, and this project will increase the likelihood and magnitude of future violations. See Air Quality and Public Health sections on Cumulative Impacts and Mitigation Measures for further discussion of this issue.

Suspended Particulates, Sulfur Dioxide, Carbon Monoxide, Nitrogen Dioxide, Oxidant, Lead, Nonmethane Hydrocarbons, and Sulfates

CEC staff believes that if the ambient air quality standards are not violated, the project as proposed should not produce adverse health impacts associated with inhalation of these pollutants. From previous experience with geothermal power plant projects, CEC staff expects that these standards will not be violated, and potential public health impacts due to the project's emissions of these pollutants should be insignificant (CEC, 1980a and b).

Radon-222

Reports indicate the radon-222 concentration in the project steam supply to be 14.8 nCi/kg (AFC, Table 1.2-3). Radon-222 steam concentrations monitored by PGandE at Units 1 through 11 ranged from 5 to 30.5 nCi/l and averaged 16.2 nCi/l (Ansbaugh, 1978). Results of PGandE's monitoring program for Units 1 through 11 also indicate that radon-222 emissions from a geothermal power plant meet applicable standards and, therefore, should not cause an adverse public health impact.

The California Department of Health Services (CDHS), however, contends that there is sufficient uncertainty about the radon-222 emission levels from geothermal power plants and their cumulative downwind impact to justify radon-222 monitoring at geothermal power plants. To reduce this uncertainty, DHS has established minimum program requirements for monitoring radon-222 at geothermal power plants, including periodic steam sampling, to allow for continued impact assessment. Oxy agreed to include a radon-222 monitoring program as a condition of certification for the proposed project.*

*Letter from R.F. Ward, Vice President/Project Manager, Occidental Geothermal, Inc., to J.H. Wazlaw, CEC, June 8, 1981.

Nonregulated Pollutants (Ammonia, Arsenic, Benzene, Boron, Mercury, ADA, Vanadium, Asbestos, and Silica)

The following analysis of impacts from nonregulated pollutants is based on steam composition data listed in Table 4 and limited ambient air quality monitoring data. Table 4 also shows the maximum expected emission rates and the maximum incremental impact on ambient air concentrations of nonregulated pollutants from the project's emissions. (The assumptions used in this analysis are found in Appendix C.) CEC staff estimated that an emission rate of 9.7 lbs/hr would increase ambient H_2S concentrations in Anderson Springs by between 2 ppb and 5 ppb (1 hour average) (see Air Quality Impacts section), or 0.3 ug/m^3 to 0.75 ug/m^3 (1 hour average) per pound H_2S emitted. For this analysis staff also assumed that an increase of 0.3 ug/m^3 to 0.75 ug/m^3 (1 hour average) would result for each pound of nonregulated pollutant emitted.

The estimates presented in Table 4 are tentative at best, because data on actual emission rates, environmental transport, and background ambient air concentrations of these nonregulated pollutants in The Geysers KGRA are either absent, of questionable validity, or not applicable in this analysis. Where numerous sources of uncertainty reduce the level of confidence in such analyses of significant effects, CEC staff attempted to reduce uncertainties by recommending pollutant source tests and environmental monitoring as a condition of power plant certification (see Mitigation Measures). In concurrence with this approach, the Lake County Air Pollution Control District included steam and ambient air monitoring of nonregulated pollutants as a condition of certification for similar projects (LCAPCD, 1980a and b).

Due to current limited use of H_2S abatement systems, it is likely that background air of The Geysers KGRA contains only negligible amounts of ADA. CEC staff concludes that resultant ambient concentrations of ADA, including contributions from the project, would be similar to the ADA concentrations presented in Table 4 and that they should not cause adverse health impacts.

The project's maximum contribution to the ambient boron concentration (annual average) is much less than the most stringent suggested ambient level, 7.4 ug/m^3 (annual average). Based on available data, it appears to be highly improbable that the project's boron emissions would adversely impact public health.

CEC staff believes that the project's emissions of arsenic, ammonia, and mercury, especially in combination with contributions from other power plants, will probably result in ambient air concentrations exceeding the Multimedia Environmental Goals* (MEG) suggested ambient goals (see Health Cumulative Impacts section). The failure to meet these goals does not necessarily mean that adverse health impacts would occur.** Rather, these failures demonstrate the need to:

*See Appendix C for a description of the MEGs.

**For example, a recent study (Larson et al., 1978) reported mean concentrations of ammonia in human breath of 157 ug/m^3 (0.23 ppm), which exceeds the MEG value by nearly a factor of 4. Therefore, the MEG value for ammonia appears to be unnecessarily stringent for public health protection.

OXY GEOTHERMAL #1

	Concentration in Steam Supply (ppm) ^a	Maximum Possible Emission Rate (lb/hr) ^b	Impact on Ambient Concentration ^c (ug/m ³)	Background Ambient Concentration ^c (ug/m ³)	Maximum Resultant Ambient Concentration ^{c,d} (ug/m ³)	Ambient Level Goal-Air ^{c,e} (ug/m ³)
Ammonia (NH ₃)	33.1	53	15.9 - 39.75	1.4-7 ^f	47	43
Arsenic (As)	0.004	0.0064	0.0019 - 0.0048	0.001-0.0044 ^h	0.0092	0.005
Boron	1.0	1.6	0.48 - 1.2	- ^j	1.2 ^j	7.4
Benzene (C ₆ H ₆)	0.05	0.08	0.024 - 0.06	0.054	0.11	7.1 ^k
Mercury (Hg)	0.0077	0.012	0.0036 - 0.009	0.001-0.018 ^l 0.005-0.4 ^m	0.4	0.01 ⁿ - 0.1
Silica (SiO ₂)	0.07	0.112	0.034 - 0.084	- ^j	0.084 ^j	-
Anthraquinone- Disulfonic Acid (ADA)	-	0.077	0.0231 - 0.0578	- ^j	0.0578 ^j	260
Vanadium (V)	-	0.05	0.015 - 0.0375	0.005-0.024 ^l	0.0615	1.2

a. Based on analysis of two wells (AFC Table 1.2-3).

b. Based on incoming steam flow rate of 1,600,000 lb/hr (AFC Figure 1.4-21). Assumes the total quantity of pollutants entering the plant in steam are emitted from the cooling tower. ADA and Vanadium emission rates assume 0.002 percent loss of Stretford solution as drift.

c. Expressed as annual average; obtained by multiplying hourly average by 0.1 (see Appendix C). Based on air quality analysis showing that each pound of H₂S emitted from the proposed facility will add a maximum of 0.3 ug/m³-0.75 ug/m³ to ambient H₂S concentrations (see Air Quality Impacts section).

d. Summation of maximum background concentration and maximum impact on ambient concentration.

e. Estimated permissible concentration; toxicity based on health effects (EPA, 1977).

f. Measurements of urban air concentrations (Wagoner, 1976).

g. Monitoring in Geysers KGRA (DWR, 1978).

h. Measured near Unit 11 (PGandE, 1979).

i. Measurements of rural air concentrations (Wagoner, 1976).

j. No background data available.

k. Estimated permissible concentration; toxicity based on genotoxic effects would be no more than 0.7 ug/m³, in accordance with the NIOSH recommended occupational level of 1 ppm.

l. Particulate mercury measurements in Geysers KGRA (Robertson, 1977).

m. Vaporous mercury measurements in Geysers KGRA (Jepsen, 1973).

n. Estimated permissible concentration; toxicity of zero-threshold pollutants based on genotoxic effects (EPA, 1977).

**TABLE 4: HEALTH-Nonregulated Pollutant Impacts
From OXY Geothermal Plant No. 1**

- o Better characterize and monitor nonregulated pollutant emissions and ambient air concentrations;*
- o Develop ambient air quality standards for these nonregulated pollutants based upon the protection of public health.**

Due to incomplete background data, CEC staff cannot meaningfully compare concentrations of boron and silica to the MEGs suggested ambient goals. Based on the large degree of uncertainty, CEC staff recommends that Oxy implement a monitoring program for ammonia, arsenic, asbestos, benzene, mercury, silica, and vanadium. Included in this program should be monitoring of ambient air concentrations in Anderson Springs and other affected population centers and steam concentrations, as described in the Compliance Monitoring Report. CEC staff and Occidental Geothermal, Inc., will jointly develop this report.

IMPACTS RELATED TO WATER POLLUTANTS

The Oxy Geothermal Power Plant No. 1 may cause degradation of water quality in local creeks (see Water Quality Impacts section and Health Cumulative Impacts section). Degradation of creeks which supply drinking water may adversely impact public health if contaminants are present in sufficient concentrations and duration. Appendix B-2 summarizes potential human health effects from consumption of water pollutants.

MITIGATION MEASURES

Oxy could achieve mitigation of potentially adverse health effects from exposure to geothermal pollutants by reducing air pollutant emissions where possible (methods of H₂S abatement are discussed in the Air Quality Impact Section). There are not demonstrated technologies for abating emissions of radon-222 or other nonregulated geothermal power plant pollutants specifically, although H₂S abatement systems, particularly upstream treatment, may scrub pollutants other than H₂S to some degree (Accurex, 1980).

The Water Quality Section addresses measures to mitigate impacts to drinking water quality. These mitigation measures should also reduce the potential for adverse health impacts related to drinking degraded water.

HEALTH RELATED MONITORING PROGRAMS

Monitoring alone does not mitigate any potential public health impacts; rather, it assists in determining the magnitude of project impacts, and those of geothermal development in general, on ambient pollutant concentrations and ultimately on public health.

DHS, in cooperation with EPA, plans field and source sampling for radon-222 and its daughter products in The Geysers KGRA. These efforts represent an

*Within the statutory authority of the CEC.

**Within the statutory authority and responsibility of California Air Resources Board, CDHS, and U.S. Environmental Protection Agency.

attempt to minimize uncertainty in anticipating the total impact on human radiation exposure associated with the operating Geysers units (Vold, 1980).

CEC staff is examining the feasibility of conducting a program for 1981 - 1982 assessing the health status of Geysers KGRA residents.

CEC staff suggests that Oxy establish a baseline ambient air monitoring and incoming steam monitoring program based upon the following:

- o Available data on background air concentrations of nonregulated pollutants are outdated and inadequate for use in determining resultant concentrations in populated areas.
- o Ongoing and future development will increase pollutant emissions at The Geysers during the operating lifetime of this project.

CEC staff further recommends that Oxy conduct the following monitoring programs:

- o Ambient monitoring for ammonia, arsenic, benzene, mercury, silica, and vanadium for one year prior to and one year after commencement of the project operation.
- o Incoming steam monitoring (operational) for ammonia, arsenic, benzene, mercury, silica, boron, and radon-222.
- o Mass balance measurements (operational) for arsenic and mercury.

The Water Quality section addresses water quality monitoring in creeks which supply drinking and recreational waters. In addition, CEC staff recommends that during power plant operation, Oxy monitor potentially toxic constituents in Gunning Creek, which supplies drinking water for Anderson Springs.

For two years after commencement of power plant operation, Occidental should monitor quarterly in Gunning Creek downstream of the project area the constituents listed in the proposed Brown and Caldwell water quality monitoring program (May 1981) plus arsenic, mercury, chromium, vanadium, oil and grease, and gross alpha and beta radioactivity. Upon agreement by Oxy and CEC, Oxy need not conduct independent monitoring if the ARM program includes monitoring these contaminants at appropriate times and locations. Oxy should not be required to conduct the monitoring if water quality protection measures, such as enclosing the Anderson Springs water supply, are undertaken.

In addition, CEC staff recommends that Occidental monitor water in Gunning Creek downstream of the project area for asbestos once during power plant construction and once during peak runoff conditions after the power plant is operational. Occidental should use sampling methods recommended at the time by the California Department of Health Services (CDHS), Air and Industrial Hygiene Laboratory (AIHL), and have the analysis conducted by a CDHS/AIHL approved laboratory. Oxy would not be required to conduct this monitoring if measures to protect drinking water sources, such as enclosing the Anderson Springs water supply, are performed.

These programs will be described in the Compliance Monitoring Report to be developed by CEC staff and Occidental Geothermal, Inc., during AFC proceedings for this project.

WORKER HEALTH

Operating geothermal power plants can pose risks to workers' health and safety. Those risks unique to geothermal plants primarily result from possible exposure to toxic and potentially carcinogenic chemical compounds associated with geothermal steam and H₂S abatement systems. Such exposures may occur during routine operation, accident or upset conditions, repair and maintenance activities, and process or system modification activities.

Workers may accidentally come into contact with many of the potentially toxic and potentially carcinogenic substances (e.g., H₂S, ammonia, radon-222 and its daughters, mercury, arsenic, and chemicals associated with H₂S abatement systems) in geothermal steam, waste streams, and when they handle chemicals used in abatement systems. Adverse effects of such exposures could include dermatitis, acute chemical poisoning, chronic illnesses, and cancers after some induction latency period (see Appendix B-1).

General Industry Safety Order 3203 (Subchapter 7 of Chapter 4, California Administrative Code, Title 8) requires employers to have an accident prevention program to reduce or prevent occupational injuries and illnesses and to conduct periodic inspections to correct unsafe conditions. Employers must comply with California Administrative Code, Title 8, Chapter 4, Group 16 (Articles 107 - 112), which refers to control of hazardous substances. The California Division of Occupational Safety and Health (DOSH) enforces compliance with state occupational safety and health standards. DOSH must inspect the plant if there is a complaint from an employee. If working conditions are found to violate an occupational standard, DOSH will determine what corrective actions are required. There is generally no means for ensuring that an employer has an adequate accident prevention program until DOSH receives a worker complaint regarding worker health and safety.

In 1976, the National Institute for Occupational Safety and Health (NIOSH) received reports that Geysers Unit 11 workers, while performing maintenance of the H₂S abatement system, developed skin rashes (dermatitis) and sore throats (pharyngitis) (NIOSH, 1978). As a result, the process was automated. Unfortunately, incidents of skin rashes have not been completely eliminated (Hahn, 1981). Such incidents lead NIOSH to the conclusion that the medical problems may be associated with exposure to H₂S abatement system residues, but the precise causal agent has yet to be identified.

Oxy will request recommendations from the CAL/OSHA Consultation Service regarding the adequacy of Oxy's worker health and safety program during project construction and operation. Methods of verifying the program's adequacy will be described in the Compliance Monitoring Report.

For reference to potential worker safety issues which CEC staff considers insignificant, see Worker Safety section of Initial Environmental Impact Evaluation, Appendix A.

TRANSPORTATION

SETTING

ACCESS

The most direct access to the proposed project, including the steam field, is from Lake County via State Highway 175 to Socrates Mine Road and then to a fire road to the site. Ford Flat Road is occasionally used by workers to commute from Cobb Village to Socrates Mine Road. With the exception of the first one and one-half miles of Socrates Mine Road the county roads are unpaved graded roads. Please refer to Transportation Figure 1 regarding roads.

CalTrans estimates the 1979 annual daily average traffic on Highway 175 to be 800 (CalTrans, Office of Traffic Engineering), and a 1980 estimate of traffic on Socrates Mine Road is 684 vehicles per day; truck traffic constitutes about 20 percent of this 1980 estimate (Lake County, 1980). In July 1980, Lake County performed a short traffic count at Ford Flat Road which showed an estimated 45 vehicles per day travel this road.

From Sonoma County, the proposed site can be reached from U.S. Highway 101 via State Highway 128 and Pine Flat Road or the Healdsburg-Geysers Road. Access is also possible from Highway 101 via the Cloverdale-Geysers Road. The Healdsburg-Geysers Road and Cloverdale-Geysers Road both go to the Geysers Resort then past Geysers 14 (via unpaved Union Oil Road) to the fire road leading to the site. The Pine Flat Road goes past Geysers 18 to the fire road to the site. The county roads are paved to the Geysers Resort, and Pine Flat Road is paved for the first 11.3 miles. The remainder of the routes are unpaved graded roads.

Waste Disposal

The most likely route for the disposal of geothermal wastes is down Socrates Mine Road to Highway 175 then on Butts Canyon Road to the disposal site near Middletown. Butts Canyon Road is a paved county road; an August 1979 traffic count by Lake County was 430 vehicles per day for this road. Subsequent population growth in the county increased this figure by 10 to 15 percent to a current level of approximately 485 vehicles per day (Lake County 1981).

ROAD CONDITIONS OF CONCERN

Socrates Mine Road--Socrates Mine Road, with the exception of the initial one and one-half miles, is a narrow, winding, unpaved road. The road, particularly the part through the Aminoil leasehold (south of the Oxy leasehold), is steep and has apparently been a source of increased erosion which can result in increased turbidity and other water quality problems in Anderson and Gunning creeks. Heavy traffic on the road damages the surface, increases excessive dust, and has severely deteriorated the road surface.

■ OXY # 1 SITE
 ▲ I.T. DISPOSAL SITE
 △ GEOTHERMAL, INC. DISPOSAL SITE

FIGURE 1: TRANSPORTATION-Regional Map

OXY GEOTHERMAL #1

Source: Geysers 16 AFC

FIGURE 2: TRANSPORTATION—The Geysers Development Area

The road generally has poor alignment, the grade is steep and the road exceeds minimum county standards in many places. The road is too narrow in most parts and lacks adequate shoulders or guardrails. There are two bridge structures located on short radius curves, and these bridges are in poor condition because of excessive use.

In summary, Socrates Mine Road is below Lake County's Mountain Standards for collector roads (Lake County standard specification resolution number 70-222). Before additional traffic is added to this road it should be upgraded (e.g., improved alignment, construction of adequate surface and base with drainage and erosion control facilities, improved safety measures such as guardrails and proper safety signs, and improved bridge structures over Anderson and Gunning creeks). Negotiations in regard to improvements and upgrading have been underway between the county and the respective road users, and agreement appears imminent. (Eugene Collins, 19 June 1981).

Butts Canyon Road--This Lake County road gives access to the Middletown waste disposal site owned by Geothermal Incorporated. Frequent use by heavy geothermal disposal trucks has caused failure of the road surface. The base, pavement, and drainage of this road is not adequate for heavy traffic. Even though Oxy has not indicated where they will dispose of their geothermal wastes (CEC staff estimates one or two trucks per month), they will probably use the Middletown waste site. Adding more heavy truck traffic to this road will only aggravate the existing impaired conditions.

Healdsburg-Geysers Road--This is a two-lane, paved county road and a major access to The Geysers from Sonoma County. This road, in sections, has poor alignment, sharp curves, and short sight distances. The pavement structure, although fair in most parts, is damaged and is in need of repair in some other parts. Sonoma County estimates that 870 vehicles travel this road in an average 24-hour period and that the traffic mix could range from 2 to 5 percent truck traffic (Sonoma County, January 1981).

In summary, sections of the Healdsburg-Geysers Road are below county standards, and CEC staff considers them inadequate and unsafe with respect to heavy loads and multi-axle vehicles. To assure safer traveling, staff recommends upgrading and improvement to Healdsburg-Geysers Road.

Cloverdale-Geysers Road--This road is a poorly maintained, narrow Sonoma County road which connects The Geysers to Cloverdale and Highway 101. The surface is extremely rough, sight distances are inadequate, and heavy trucks have problems negotiating sharp radii curves.

There is a one-lane bridge over Squaw Creek which may be inadequate for heavy truck crossings. The travelway and shoulders in some parts are eroded away, leaving the effective width of the road at about eight feet, which is barely enough for one lane of traffic.

CEC staff concludes that this road is in poor condition and its use by construction traffic must be prohibited until proper maintenance and safety measures are implemented. The ability to implement this mitigation measure rests with Sonoma County.

Ford Flat Road--This three-mile long narrow dirt road winds through mountainous terrain. It connects Socrates Mine Road to the Whispering Pines and Cobb area in Lake County. It could also serve as a short-cut to Highway 175 and Bottle Rock Road leading to the Kelseyville waste disposal site. This road is inadequate for heavy truck traffic. Lake County (Eugene Collins, 21 May 1981) emphasizes the fact that commute traffic on this road causes excessive dust and noise problems for the residences along the road, and its use must be limited to local residents.

Pine Flat Road is a long, narrow, winding road in Sonoma County. It is poorly maintained with a deteriorating road surface. The last portion of the road is graded, but the road as a whole is inadequate for heavy truck traffic.

Safety--Many of these roads have a high potential for accidents. The following table lists accident statistics for the roads as reported to the California Highway Patrol, although reported accidents do not necessarily render complete and accurate statistics.*

	1979	1980
Highway 175 near Cobb Village	23	26
Butts Canyon Road	4	4
Socrates Mine Road	0	3
Healdsburg-Geysers Road	10	17
Pine Flat Road	2	2
Ford Flat Road	0	0

IMPACTS

LIGHT TRAFFIC

During the peak construction phase of the project, Oxy estimates that 65 autos/light trucks will travel to and from the project area per day. The majority of the trucks will use the Socrates Mine Road, and the light traffic is expected to be divided equally between Socrates Mine Road and Healdsburg-Geysers Road. This small increase in light traffic will not significantly affect the local transportation network. To further decrease the light traffic impact, Oxy will furnish buses for their workers (see "Socioeconomic" section of the EIR).

*(Lt. Flint, CHP Lake County; Officer Gardner, CHP Santa Rosa; 23 February 1981)

HEAVY EQUIPMENT TRAFFIC

Construction traffic will reach the power plant site from Middletown, using State Route 175 and Socrates Mine Road. Oxy estimates that an average of five heavy trucks will travel to and from the site each day during construction (81-AFC-1). This number will reduce to about 10 trucks per week during the operation phase of the plant.

The main impacts of Oxy construction on the roads are summarized below.

Socrates Mine Road--Oxy plans to transport about 40,000 tons of cement, aggregate, gravel, and asphalt to the site via Socrates Mine Road. Assuming an average payload per truck at 25 tons, it will take 1,600 trips to take the required material to the construction site. In addition, heavy construction equipment and water trucks will travel over this road. Oxy estimates that about 1,900 tons of steel and concrete blocks will be transported via this road. In addition, heavy construction equipment such as D8 tractors, concrete mix trucks, and heavy equipment components for the power plant travel via this road. Again, assuming the trucks are carrying 25 tons of payload each, it will take an estimated 100 trips to haul necessary material and equipment to the site.

The conditions described in the setting portion of this discussion will be aggravated by construction of Oxy #1. Unless these conditions are mitigated, significant adverse impacts to transportation and safety will result.

Cloverdale-Geysers Road--Oxy indicates that no construction truck traffic will use this road and there is no accurate estimate of passenger car trips which will occur on this road due to the proposed development. CEC staff estimates that an increase in traffic on this road due to Oxy #1 construction will not be significant.

Ford Flat Road--Construction of Oxy #1 may generate some traffic on Ford Flat Road, in addition to the present 45 vehicles per day. This could only aggravate the conditions described in the Setting. CEC staff estimates that an increase in traffic on this road due to Oxy #1 construction will have minor significance.

Butts Canyon Road--This is a major access road to the Middletown waste disposal area, and if Oxy decides to use this waste disposal area, trucks hauling geothermal waste to the site could exacerbate the conditions described in the Setting. Staff estimates that Oxy's contribution to an increase in truck traffic once the power plant is operable will not independently cause significant deterioration to this road. Cumulatively, however, Oxy's disposal trucks will add to the existing problem.

Highway 175--If the Kelseyville dump site were used there would be an increase of traffic on this road, and, as a result, traffic safety would decrease somewhat.

Additionally, one must consider truck traffic associated with steam field development. Full development will require 12 wells yielding perhaps 100 loads of sludge per well. This would generate 1,200 truck loads of sludge for full development prior to operation. This volume could contribute significantly to traffic in the area.

The high volume of traffic associated with the Oxy project, particularly at peak periods, could result in a significant impact on traffic safety. Presently, Socrates Mine Road is steep and winding with much traffic. Highway 175, Butts Canyon Road, and Bottle Rock Road also contain curves and are experiencing increases in traffic. The Middletown Unified School District (21 May 1981) has stated its concern for the safety of school children during the hours of pickup and delivery, due to the mixture of heavy geothermal truck traffic and school buses. In addition to traffic safety, many trucks carry toxic materials (chemicals, wastes) with the potential for hazardous spills.

Access Road--Access to the plant will be gained from an existing graded fire road through Birdsong Meadow to the site vicinity (approximately 1.5 miles distance) and then on separate access roads to the plant and well sites. SMUD proposes to widen this fire road in parts and pave it in order to handle construction traffic to the nearby SMUDGE #1 site, and Oxy indicated (April 24, 1981) that they will share the cost of improving and maintaining the road. Improvements to the road through Birdsong Meadow will be completed by winter of 1981, but the remainder of the fire road will not be paved until construction is completed during the summer of 1983. Paving the road will alleviate dust problems from vehicles and will decrease erosion and sediment transport to streams. CEC staff considers these proposed access road improvements to be acceptable. The proposed mitigation measures, such as erosion control measures, hydroseeding exposed disturbed surfaces, and placing and maintaining culverts, should decrease or prevent sediment from impacting the Cobb Creek and Calm Creek drainage. (See Biology section of the EIR for impact and mitigation to biological resources.)

MITIGATION MEASURES

Oxy will maintain the roads within the leasehold. County roads are maintained by the respective county. If the county determines that roads within its jurisdiction are being abused by heavy truck and construction equipment (load limits are set by the County Road Commission), the county may request the involved developers to participate in improvement and maintenance costs.

The extent of deterioration of other private and county roads due to Oxy #1 alone will likely be insignificant if those roads are properly managed and maintained. However, cumulative impacts to such roads, resulting from all geothermal development, may still be significant.

A suggested mitigation (CEC Workshop, 21 May 81) of the potential conflict between project related vehicles and school bus traffic would be to schedule project traffic to avoid the times of school traffic. Staff concurs that this measure should be thoroughly explored and implemented if possible.

Socrates Mine Road--As mentioned above, Socrates Mine Road, in its present condition and alignment, is below county standards and poses a traveling hazard. Staff feels that improving the road is necessary. Major road users (Aminoil, PGandE, Union Oil, SMUD, Occidental, Shell, and NCPA) are negotiating with Lake County to improve and upgrade the road. A proposed agreement to rebuild the road and a final design for the improvements have been submitted to Lake County for review and approval appears imminent (Eugene Collins 19 June 1981).

The plans for improvement to Socrates Mine Road include widening the road in certain sections, better alignment through tight curves, improving or replacing structures over Anderson and Gunning creeks, proper base and surface throughout the improved section, and proper drainage and erosion mitigation measures. The proposed improvement schedule would finish work on the road in the summer of 1981. If these plans are implemented, they will result in safer traveling on Socrates Mine Road.

Butts Canyon Road--The section of Butts Canyon Road leading to the Geothermal Inc., waste disposal area should be improved and maintained with proper base, surface, and drainage systems. The question of funding is uncertain, although the county may apply for federal funds (Collins, 21 May 1981).

Ford Flat Road--If Socrates Mine Road is improved, geothermal traffic on Ford Flat Road may decrease to an insignificant level. This assumes that travelers would prefer a paved, faster, and better aligned road to the winding, graded Ford Flat Road.

ENERGY AND MATERIAL RESOURCES

SETTING

STEAM SUPPLY

The most important control to a geothermal power plant is the steam which drives the system. As explained in the Geology section of the EIR, not enough is known about the size and nature of the steam reservoir to accurately predict depletion rates; however, CEC staff recognizes that the steam reservoir is finite, and that the Oxy design requires approximately 1,500,000 lbs/hr. CEC staff expects that by 1986, with as many as 24 geothermal plants on line, total steam use in the KGRA will approximate 28,305,000 lbs/hr. This estimate includes PGandE units 1 - 18, Oxy #1, NCPA 2, SMUDGE #1, DWR Bottle Rock and South Geysers.*

OTHER ENERGY INPUTS

Construction of the power plant and related facilities will consume various forms of energy. The Oxy AFC (Section 9.3) indicates the types of construction equipment which they will use, most of which will rely on gasoline and diesel fuel. Once construction is complete, Oxy will use small amounts of fossil fuel to operate and maintain the facilities and will rely on the power plant itself to supply the electricity needed internally.

MATERIAL RESOURCES

Construction of the proposed power plant will require the following materials: concrete, steel, aluminum, metal alloys and catalysts, paint and wood.

IMPACTS

STEAM SUPPLY

Steam consumption as a result of the operation of Oxy #1 and other geothermal units in the KGRA may eventually deplete the steam supply. However, neither the characteristics of the reservoir nor the rate of depletion as compared to the rate of recharge is fully understood at this time, so CEC staff cannot accurately predict reservoir depletion rates. Nevertheless, staff is aware of reported pressure losses in the KGRA (Geyser 16 Draft EIR, p. I-47). The Oxy #1 plant will contribute incrementally (1,500,000 lbs/hr) to the overall steam loss in the KGRA. By 1986, Oxy plus other geothermal plants may consume steam at an approximate rate of 28,305,000 lbs/hr.

*Sources: CEC staff draft, May 1981, Potential Development of Geothermal Electric Power Resources in The Geysers, Table 2, and CEC staff draft, June 1981, Mitigation of Hydrogen Sulfide Emissions in The Geysers KGRA, p. 13.

OTHER ENERGY INPUTS

Fossil fuels and electrical energy used to construct and operate Oxy #1 will be insignificant in comparison to the amount of electrical energy the plant will produce and the amount of fossil fuels which Oxy will save by displacing their use with geothermal energy for electrical production.

MATERIAL RESOURCES

The amount of construction material used in the Oxy #1 plant represents an insignificant portion of the available supply of these materials.

MITIGATION MEASURES

STEAM SUPPLY

The Oxy design incorporates the use of independent dual turbines, as well as turbine bypass devices. These two features will (1) reduce the likelihood of a total plant shutdown, and (2) in the event of a shutdown, will circulate steam via the turbine bypass through the air abatement systems in order to reduce air pollution which would otherwise result from steam venting freely into the atmosphere.

Oxy will employ governors to throttle back steam in order to keep the power plant to an 80 MW net output. One could view the use of governors as a steam conservation technique, since "unwanted" steam would not be used. Another mitigation measure to conserve the steam resource would be to use a more efficient turbine design which would make power more efficiently and use less steam to do it.

OTHER ENERGY INPUTS

Oxy and its subcontractors should minimize the use of gasoline and diesel fuel by consolidating trips and using fuel-conservation operational procedures.

MATERIAL RESOURCES

When they are no longer needed for the project, Oxy should recycle such materials as steel, aluminum, copper, and wood.

CULTURAL RESOURCES

SETTING

Cobb Mountain marks the geographical boundaries of territories traditionally claimed by the Western and Northern Wappo and Central and Eastern Pomo and Lake Miwok Indians (Kroeber, 1925). Kroeber reports a Wappo town, Tekenantsonoma, was situated within the developed KGRA. Its location has not been precisely determined, although a large archaeological site has been recorded by Fredrickson (1974). This large, dispersed site is characterized by a large house depression, possibly the remains of a dance house, and a number of isolated groups of house pits suggestive of single family hamlets.

A dispersed community organization such as at Tekenantsonoma was common for ethnographic groups in the North Coast Ranges (Heizer, 1975). In general, each local community appears to have had a single permanently inhabited town which served as a politically autonomous group, which may have numbered from about 100 to perhaps 300 individuals. Smaller sites, occasionally made up of only a single household, would also be a part of the settlement system, as would be task-specific sites such as camp sites, hunting stations, food processing stations, quarries and manufacturing stations, and sites of religious significance.

Because of different economic foci, experts believe that settlement systems contrasting with the ethnographic Wappo existed in the North Coast Range during earlier time periods. Details of earlier social and environmental relationships are scant, since little archaeological work has been done within the North Coast Ranges.

A cultural resources survey of what is now the Occidental federal leasehold was conducted in 1976 as part of a Burmah Oil Company geothermal leasehold survey (Pacific Bioarchaeology Laboratory, 1976). Additional cultural resource investigations within the leasehold were conducted by Frederickson and Hayes, 1978; Peri and Patterson, 1978; PGandE (Frederickson), 1978; and Origer, 1980. The findings of these studies are summarized below.

IMPACTS

PALEONTOLOGY

Project impacts to paleontological resources should be limited, since no resources have been identified within the leasehold. However, Franciscan melange units, which commonly contain fossiliferous chert, occur. These melange units may contain as yet unmapped and possibly fossiliferous chert. If excavation takes place in these Franciscan melange areas, impacts to paleontological resources could occur. Provided the specific mitigation measures are implemented no significant adverse effects will take place.

ARCHAEOLOGY

Prior studies have identified one prehistoric archaeological site, CA-LAK-711, in the study area. CA-LAK-711 has particular significance because of its high elevation, its hinterland location at the presumed boundary between the Wappo

of The Geysers and the Lake Miwok of southern Lake County, and its location on or near an aboriginal trail (see AFC, Figure 5.7-1). A Native American consultant of Lake Miwok ancestry identified the general vicinity of CA-LAK-711 as an area within which during his lifetime Indians hunted bear and deer. The consultant suggested that the site may have been a hunting camp from which large game was pursued. In addition, the consultant suggested that the site was a border outpost from which the local Lake Miwok could guard their remote hunting and collecting grounds. Excavation testing indicated the archaeological site contains cultural materials to a depth of 190 cm below the surface. The site was listed on the National Register of Historic Places in 1980. No other prehistoric archeological resources were identified.

No construction activity will take place in the immediate vicinity of the site. Nonetheless, Occidental will be required to establish a buffer zone around the site to eliminate the possibility of accidental damage. With the establishment of the buffer zone, there will be no impact to archaeological resources.

NATIVE AMERICAN SITES AND ETHNOGRAPHY

Review of ethnographic and archaeological literature and field visits with Lake Miwok and Wappo consultants revealed no sites of sociocultural significance within the leasehold. However, it was noted that several plants of ethnobotanical importance were present and that a major Native American trail once passed through the leasehold. The trail followed the ridgeline of the Mayacmas Mountains and gave access to Clear Lake, the greater Geysers region, and Knights Valley, serving as an important link between Indian communities of the region. No traces of the trail could be identified in the field. Archaeological site CA-LAK-711, discussed more fully above, was identified by Indian consultants as a hunting and border outpost location. Therefore, no impacts will occur to ethnographic resources.

HISTORY

Although no historic properties were identified within the leasehold, a literature search revealed that the area had been used for logging, mining, recreation, and stock raising. A homestead patent was taken out in 1903 but was cancelled in 1907. Following passage of the Homestead and Stockgrazing Act of 1916, the land was patented and the current owner holds rights to surface use of the land. Evidence of logging was found within the leasehold, while evidence of recreational use and mining were restricted to the leasehold's easternmost portion. None of the above activities resulted in remains that warrant site status. The project will not impact any historic resources.

MITIGATION

1. If an excavation greater than four meters in depth is required in an area of Franciscan melange, a field check by a qualified paleontologist or geologist will be made after the excavation to determine if any fossil-bearing chert was uncovered. Occidental will notify the CEC within 24 hours of the geological or paleontological specialist's evaluation of the resource. Should mitigation be necessary, representatives of the CEC, the Bureau of Land Management's Ukiah office, and Occidental will meet

with the specialist within two working days of this notification to discuss proposed mitigation measures. All construction or excavation activity in the resource area shall remain stopped, pending resolution of this matter.

2. Occidental will protect site CA-LAK-711 by a buffer zone to be established around its perimeter. The buffer zone should be no less than two hundred feet (65 meters) in width.
3. If other as yet unidentified archaeological materials are discovered or unearthed during construction, work in the immediate area will be halted and a qualified archaeologist will be consulted to evaluate the find. Occidental will notify CEC within 24 hours of the resource discovery and the work stoppage. Within two working days of this notification, representatives of the CEC, the Bureau of Land Management's Ukiah office, and Occidental will meet with the archeological specialist to discuss the possible significance of the resources and proposed mitigation measures. Pending resolution of this matter, construction activity in the resource areas shall cease. If agreement between Occidental and the CEC regarding the mitigation plan cannot be reached within one week following Occidental's notice to the CEC, the matter shall be considered under the provisions of the CEC's Dispute Resolution Procedures.

LAND USE

SETTING

Before the advent of geothermal development, principal land uses in The Geysers KGRA were recreation (predominantly hunting) and mining. Mining activities have been discontinued and recreation has been limited by restricted and, in some areas, difficult access. Extensive use of nearby areas (e.g., Cobb Mountain) for recreational purposes continues. However, geothermal exploration and development have expanded into the site area in recent years. SMUD's Unit #1 site lies within one mile to the west of the proposed Occidental site. PGandE's Units 9 and 10 lie slightly further to the northwest, while PGandE Units 13 and 14 lie to the west and southeast, respectively.

Occidental has already acquired geothermal leases for the leasehold from the federal government, numbers CA 5636 and CA 5637. Surface land rights do not belong to Occidental, rather they belong to the Charles T. Simmons family. The U.S. Department of Interior governs the relationship between the two land use parties through administration of mineral reserve leases on 1916 Homestead Act Lands.

The leasehold for the proposed project contains approximately 550 acres, of which about 480 acres are in Lake County with the remainder in Sonoma County. That portion of the leasehold in Lake County is "Extensive Agriculture" in the Lake County General Plan; its zoning is "unclassified." These designations allow geothermal development; the zoning requires a use permit. Lake County's General Plan is currently undergoing revision and should be adopted late this year (1981). Discussions with Lake County Planning Department staff indicate geothermal development will continue to be allowed under the new General Plan. The 70 acre portion of the leasehold in Sonoma County lies within an area designated in the Sonoma County General Plan as primary geothermal resource area.

IMPACTS

Development of the proposed Occidental project will continue the current and prospective principal land use in this portion of the KGRA. As proposed, the project complies with both Lake and Sonoma County General Plans.

To date Occidental and the surface rights owner have not reached agreement over the location of the power plant and related facilities. Due to this, Oxy has sought a legal solution through the judicial system. Since resolution of this situation is not within the authority of the CEC, the EIR will contain no further discussion of the matter. If a decision is rendered prior to the final EIR, it will be reported.

MITIGATION

No mitigation measures are required.

AESTHETICS

SETTING

The proposed Oxy development is located within the Mayacmas Mountains, a northwest trending range characterized by steep hillsides and deeply incised valleys. The leasehold is located on a prominent ridge that drops away to the southwest of Cobb Mountain (elevation 4,722 feet). Other visible landforms surrounding the leasehold besides Cobb Mountain on the north are Ford Flat (elevation 2,500 feet) to the east, Little Geysers (2,200 feet) to the south, and Burned Mountain (3,800 feet) to the west. Actual topographic relief within the leasehold is mild with only several hundred feet difference in vertical elevation. The location is at the top of the Anderson and Gunning creeks watershed.

A variety of plant communities provides a dense vegetative cover over most of the leasehold. A majority of the proposed site is covered by chaparral species, mostly coarsely textured, grey-green low-lying shrubs. Other plant communities present, such as grasslands and oak woodlands, provide a visual contrast to the dominant vegetative cover.

Off site, the leasehold is mainly visible to areas east of the proposed development. Views over five miles from the site from the north, south, and west are interrupted by intervening ridgelines.

To the east, the site is visible from points within Collayomi and Long valleys, including locations in Anderson Springs, Middletown, and along Highway 29 and 175. However, views from those recreational developments along Highway 175 in Cobb Valley-Whispering Pines, Cobb, and Pine Grove are obstructed by topography and heavy vegetation (AFC, p. 5-96). Foreground views of the area are also mostly limited to the east, mainly along Socrates Mine Road. Foreground views from other directions are mainly from areas which already contain geothermal development.

Land scars which result from geothermal exploration activities are visually evident within the leasehold. These include access roads and the three well pads, with a fourth planned.

The proposed transmission line would be approximately 1 mile long and require three 140 foot towers. The proposed transmission corridor would traverse the ridge above the power plant and then descend into the Big Sulphur Creek drainage before connecting with an existing line. Only one of the towers would be visible from the populated areas to the east. The other alternative route, however, would create a greater visual impact with three transmission towers visible to the east.

IMPACTS

Impacts to the aesthetic qualities of an area are not easily quantified, especially scenic values. Generally, aesthetic impacts resulting from development depend on the perceived degree the original environment is altered. This environment includes both man-made features, such as roads, and natural features, such as land forms or vegetation.

Development of the steam field, power plant, and transmission line will convert an essentially undisturbed area into an industrialized one. While the actual disturbed area will be only a small percentage of the total leasehold, CEC staff anticipates short-term unavoidable, adverse aesthetic impacts during the construction phase of development will result. This stage of development includes the construction of roads, drill pads, the power plant, and the associated clearing and grading activities. Those development activities occurring near the ridge top will create the most significant visual impacts and would include the power plant, transmission line, and road construction. These activities will substantially alter the natural contours of the hill-sides, and the areas cleared of vegetation will present a sharp contrast to adjacent areas. The power plant will be visible to certain areas within Long and Collayomi valleys. The Cooling Tower plume will even be more significant visually than the power plant. This will lessen the visual value for the residents and many tourists of this area.

During operation of the facilities, these adverse visual impacts will continue.

Adverse aesthetic impacts during the construction phase include a sharp increase in noise and road traffic. These impacts would affect residents of those communities located along the major access roads into the KGRA. However, their effect will be minimized once the construction phase of development is completed. Road traffic, noise, and other impacts will decline to an insignificant level. Another adverse impact will be a lessening of aesthetic values of Anderson Creek. CEC anticipates degradation of Anderson Creek and possibly Gunning Creek will result from the proposed Occidental development. This water quality degradation will be sufficient to result in aesthetic impacts as well. (For further discussion regarding impacts and mitigation see Water Quality section.)

MITIGATION MEASURES

Certain impacts to aesthetic resources can be lessened through the implementation of mitigation measures. Oxy plans the following measures to reduce the visual impacts of the proposed project.

1. Reestablish vegetation on land surfaces disturbed by geothermal development.
2. Use colors and nonreflected materials to minimize the contrast between the development and the natural background.
3. Landscaping, erosion, and sedimentation control.
4. Selection of the preferred transmission line alternative.
5. Other mitigation measures such as noise, air, and water pollution control are discussed under their appropriate sections.

By implementing these measures Oxy can reduce most short-term unavoidable aesthetic impacts that occur during the construction phase. CEC staff anticipates that visual impacts will continue throughout the life of the project. Additional aesthetic impacts resulting from water quality degradation may occur in Anderson Springs.

III. CUMULATIVE ENVIRONMENTAL ANALYSIS

The project will contribute to the cumulative impacts of geothermal development in The Geysers KGRA, which are significant and increasing.

These cumulative impacts are made no less significant by the fact that substantial portions of the KGRA have, in effect, become "industrialized" due to geothermal development. The proliferation of well pads, access roads, steam conveyance lines, transmission lines, and power plants is gradually altering the undisturbed natural environment of The Geysers KGRA, and no amount of mitigation at individual project sites can alter this basic fact.

CEC staff predicts maximum develop of the KGRA at 2,700 MW dry steam production by 1992, with an additional 550 MW from hot water production by the year 2000.

Accurate assessment of the cumulative impacts of geothermal development at the KGRA is in a fledgling stage. Although this document attempts to address cumulative impacts, each of these effects should be viewed as extremely speculative. There is simply not enough data to make an accurate statement at this time nor is it logical to propose mitigation of these impacts until the needed data is available. For this reason CEC has initiated several generic studies on the matter: (1) "Mitigation of Hydrogen Sulfide Emissions in the Geysers KGRA", CEC Draft, July 1981; (2) "Potential Development of Geothermal Electric Power Resources in the Geysers", Draft scheduled for distribution in August 1981; and (3) "Status and Overview of Cumulative Impact Issues in the Geysers", CEC Draft, estimated for distribution, late 1981. These studies will address the following topics: health effects of H₂S; water-related resources; biological resources; socioeconomic; seismic performance and design criteria; erosion/sedimentation potential; transmission system; and air quality monitoring. Once these studies are complete we will have an accurate picture of the cumulative impacts of geothermal development at the KGRA. At that time it will be appropriate to discuss proposed mitigation of these impacts.

CATEGORICAL CONCERNS

It is difficult to determine to what degree impacts associated with the Oxy #1 project will contribute to the cumulative impacts of the overall development in the KGRA. Cumulative impacts are of concern in the areas of land use and aesthetics, transportation, air quality, public health, water quality, erosion and sedimentation, biological resources, and safety.

Current and Anticipated Geothermal Development

The following list summarizes the status of geothermal development within the KGRA.

	<u>Unit</u>	<u>Net Capacity (MW)</u>	<u>Cumulative Capacity (MW)</u>	<u>Commercial Operation</u>	<u>Target for Operation</u>
<u>Operational</u>					
PGandE	1	11	11	9/25/60	
	2	13	24	9/13/63	
	3	27	51	4/28/67	
	4	27	78	3/02/68	
	5	53	131	12/15/71	
	6	53	184	8/18/72	
	7	53	237	11/23/72	
	8	53	290	11/23/72	
	9	53	343	10/25/73	
	10	53	396	11/30/73	
	11	106	502	5/31/75	
	12	106	608	3/01/79	
	13	135	743	4/15/80	
	14	110	853	9/12/80	
	15	55	908	6/17/79	
<u>Under Construction</u>					
PGandE	17	110	1,018		1982
	18	110	1,128		1983
NCPA	2	110	1,238		1983
SMUDGE0 #1		72	1,310		1983
<u>Approved for Construction</u>					
DWR Bottle Rock		55	1,365		1984
<u>Proposed</u>					
DWR South Geysers		55	1,420		1986
PGandE 16		110	1,530		1983
Oxy Geo #1		80	1,610		1984
<u>To Be Proposed</u>					
NCPA	1	66	1,676		unknown
NCPA	3	55	1,731		unknown
PGandE	20	110	1,841		unknown
Total			1,841 MW		

CUMULATIVE IMPACTS--GEOLOGY

SETTING

Much of the information needed to define the size and characteristics of The Geysers steam reservoir is owned by steam developers who consider it highly proprietary. The state Division of Oil and Gas currently estimates the geographical area of the steam reservoir to be about 16,000 acres, but cautions that this estimate could be in error by a factor of 2. Other reservoir characteristics are subject to equal or greater uncertainty.

In general, CEC staff and other geothermal experts consider the reservoir depletable. Thus, the geothermal heat and fluids consumed by each steam development project hasten depletion of the reservoir, although the long-term cumulative effects cannot be accurately evaluated at this time. Because surface geothermal phenomena (fumaroles, hot springs, etc.) depend on the heat and fluids contained in the reservoir, reservoir depletion will result in a decrease or cessation of these phenomena.

Studies by the U.S. Geological Survey indicate that geothermal development of the steam field induces seismicity and subsidence in the KGRA.

As discussed earlier, unstable slopes and landslides pervade the steam field and constitute a serious environmental consideration.

IMPACTS

At present, it is not possible to accurately evaluate the impact of this or any other development project on the steam resource or on surficial geothermal phenomena. The state Division of Oil and Gas is currently completing a report which better defines some important reservoir characteristics. In addition, CEC, in cooperation with DOG, is studying the feasibility and utility of mathematically modeling The Geysers steam reservoir. Potentially, such a model could provide an effective tool for assessing reservoir characteristics, capacity, longevity, and the effects of development.

Based on U.S.G.S. studies, induced microseismic activity and subsidence are unlikely to directly cause significant adverse impacts. They could result in increased potential for fault rupture and landslides in the steam field.

Slope instability and landslide potential need to be evaluated on a case-by-case basis. Presently, the potential for induced or accelerated landsliding in the steam field is being addressed by CEC for power plants and transmission lines and by DOG or U.S.G.S. for well pads.

MITIGATION MEASURES

It is not presently possible to determine what, if any, measures are necessary or desirable to minimize reservoir depletion. Based on results of a few hypothetical studies, it appears that to effectively increase reservoir longevity,

injection of fluids into the reservoir must be massive (200 percent or 300 percent of amount of produced fluid) and initiated early in the production history. The environmental costs of injecting this much water (most of which would be reclaimed surface water) may be prohibitive.

Induced seismicity and subsidence are probably not serious enough to warrant any mitigation efforts.

Landsliding should be evaluated and mitigated on a case-by-case basis as is presently done by DOG and CEC.

CUMULATIVE IMPACTS--SOILS

SETTING

The California Department of Conservation in 1972¹¹* described the problems affecting soils along the North Coast of California as follows:

"The degradation of soil resources in north coastal watersheds is indicated by accelerated soil erosion, soil mass movements, and accelerated stream bank erosion. These problems are largely man induced, resulting from over grazing, road construction, timber harvesting, and conversion of forest to rangeland. Watershed disturbances of this nature increase runoff, thereby accelerating stream bank erosion."

As an example they cite soil erosion rates of 15 tons/acre/year and 7 tons/acre/year in the Eel and Mad River basins, respectively. These rates are much higher than the one to three tons/acre/year these soils can sustain. Similar conditions exist on the Oxy leasehold. The predicted loss from the Oxy site of 200 tons/acre/year during construction and 6 tons/acre/year after construction exceed recommended rates.

Roads, e.g., those proposed by Oxy, have increased erosion from 2 to 360 times existing levels depending on the total length of roads per unit of drainage area. A 1971 study by the Department of Conservation¹² indicated roads to be a major cause of soil erosion, as shown in the following table:

Water Erosion Due to Road Density

<u>Area</u>	<u>Density*</u>	<u>Erosion</u>
North Coast	1 mile/mile ²	0.03 tons/acre
Lake Tahoe	2 miles/mile ²	0.20 tons/acre
Colma Creek	13 miles/mile ²	8 tons/acre

*Density equals miles of road length per square mile of drainage basin.

Density of access roads in the Anderson Creek watershed portion of the Oxy leasehold will be 2.29 miles/mile². Steam lines add an additional 1.5 miles/mile² of disturbance. A study conducted by the U.S. Department of Agriculture and the California Department of Water Resources^{13,14} indicated that 51, 67, and 85 percent of the sediment recorded in the Klamath, Trinity, and Smith River basins, respectively, was due to road construction.

*Note: All footnotes in this section are keyed to Soils References, which are listed at the back of the Project-Specific Soils section.

Near The Geysers KGRA the Dry Creek Basin yielded sediment at a rate of nine tons/acre/year,¹⁵ the highest rate in the Russian River Basin. The erosion is attributed to the conversion of 40 percent of the forest land to rangeland in the basin in the early 20th century.

IMPACT

Oxy will remove the vegetation and disturb soils on 51 acres or 9 percent of their leasehold. Ordinarily the amount of disturbance proposed by Occidental would not be alarming were it not for the fact that the disturbance is at the headwaters of Anderson and Gunning creeks. Not only is there potential to lose the soil and vegetation resources but also to degrade a domestic water supply.

Of particular concern is the proximity of Drill Pad B to Gunning Creek and the encroachment on Anderson Creek of the access road from Drill Pad C to Drill Pad B. The Maymen-Etsel and Harbin-Whispering Soil Associations underlying Drill Pad B are highly erodable and repose on steep (30 - 50 percent) slopes. The U.S. Geological Survey¹⁶ characterized the revegetation of the 60 foot cut and fill slopes as "extremely difficult of accomplishment." As stated earlier, the conversion of forested and woodland slopes to grassland has resulted in excessive soil losses under similar circumstances. Initial revegetation of cut and fill slopes with grasses, as proposed by Occidental, will result in higher soil losses than if the brush covered slopes remained undisturbed.

The access road from Drill Pad C crosses five soil complexes and associations en route to Drill Pad B. However, the majority of the route is underlain by the Maymen-Hopland-Woodin Association and Maymen-Estel Complex, particularly where it crosses Anderson Creek. Not only are these soils highly erodable but also the fertility value is low with a magnesium-calcium imbalance. Taken together these properties indicate a high erosion potential and difficulty in revegetation of disturbed slopes. Similar soils developed on the Franciscan Formation at the University of California Experiment Station at Hopland, produced 10 times as much sediment (1.9 tons to 19 tons per acre) after the native vegetation had been removed and the slopes reseeded.¹⁷

What has been said for Drill Pad B and the access road from Drill Pad C to B could also be said for the other drill pads. In the "Five Tract EAR"¹⁸ the Bureau of Land Management stated that generally the soils on Tract D (Occidental leasehold) are low in fertility, with nitrogen the most limiting nutrient. However, the soils developed from/on serpentines, e.g., Henneke (Drill Pad C), are very deficient in nitrogen phosphorous and calcium and moderately so in sulfur, molybdenum, and potassium.¹⁹ Calcium/magnesium imbalances will inhibit the establishment of vegetative cover unless corrected by the application of fertilizer and/or soil amendments.

Infiltration into the soils is moderately rapid. However, the soils are mostly shallow over nearly impervious bedrock with low water holding capacity. Any loss of native soils due to the anticipated high rates of erosion will further exacerbate a somewhat ungenerous environment for revegetation of cut and fill slopes.

Existing erosion hazards are high. The hazard will become higher yet when slopes are denuded of vegetation. The removal of existing vegetation under these conditions is a calculated risk. Whether or not it is a good or bad calculated risk depends on the effectiveness of the mitigation proposed by Oxy and the frequency, intensity, and duration of rainfall during and after construction.

MITIGATION

Oxy will utilize the same mitigation techniques for the drill pads and access roads as described for the plant site. Of particular importance is the paving of the access road from Drill Pad C to B. Access roads should be chip-sealed prior to the rain season. Paving the roadway, curbs, and borrow pits would decrease the erodable area and prevent rutting of the road. Oxy will also divert as much as possible of the runoff from Drill Pad B away from Gunning Creek and into Anderson Creek. A check dam or sedimentation pond should not be installed if access to the containment requires construction of a major road. Such an access road may cause more sedimentation than the power plant itself.

CUMULATIVE IMPACTS--WATER QUALITY

SETTING

Staff of the United States Geological Survey introduced "Environmental Assessment 131-81"³⁶ for Occidental Drill Pad B with the following analysis:

"Although the impacts of each of the undivided (geothermal) projects in The Geysers thus far have been considered insignificant in the sense of the National Environmental Protection Act (NEPA), the cumulative impact of development in the Geysers has affected, or may be expected to affect, air and water quality; and soil; the infrastructure of surrounding counties, especially Lake County; wildlife habitat; the steam reservoir; the aesthetic quality of the landscape; and the quality of life for people living in or near the developed portions of the steamfield.

The cumulative effects of development cannot be adequately assessed through case by case Environmental Assessments such as this one. Development has changed the character of the landscape, once relatively wild and roadless. Vegetation has been cleared from roughly 1500 acres or 20 percent of the field. The resulting small (generally 2 to 3 acre) patches and connecting ribbons of barren ground are dispersed over an area ten times as large. Both the United States Fish and Wildlife Service and the California Department of Fish and Game are concerned over the ecological impacts of disturbing habitat over so large an area.

Water quality may be affected by increased erosion caused by loss of vegetation; roadway, drill pad, and sump construction and use; alteration of natural drainages by cut and fill operation's and an increase in heavy equipment traffic, especially those carrying toxic materials which might spill (there have been spills in the past). Even with the diligent use of erosion control, revegetation and careful engineering, sedimentation rates increase with the addition of each cleared roadway or drill pad. Roads can be upgraded as use increases, to accommodate heavier and more frequent traffic. The soils at The Geysers are highly erosive (sic), even under natural conditions.

The erosion rates during construction and before revegetation may be twenty times the natural rate. Loss of soil makes revegetation much more difficult to accomplish, increases siltation into streams, and may result in landsliding and slumping."

IMPACTS

The Anderson Springs community water supply is particularly vulnerable to degradation by geothermal resource development in the Anderson and Gunning creeks watersheds. Because there is a need to protect the quality of life of Anderson Springs residents, there is a unique concern for development within the Occidental leasehold. Previously proposed power plants within The Geysers KGRA have not had the potential to directly impact a public water supply.

*All footnotes in this section are keyed to Water Resource References at the end of the Project-Specific Hydrology/Water Quality Section.

The Gunning Creek watershed, from which 70 percent of the Anderson Springs water supply is derived, is a relatively pristine watershed. Portions of Anderson Creek show clear evidence of sediment degradation due primarily to access road and geothermal development. Presently, Aminoil has developed drill pad sites in the Gunning Creek watershed. Current indications are that Union Oil Company also proposes to develop well pads at the head of Gunning Creek. Full leasehold development of the Gunning Creek watershed has a potential to seriously degrade the municipal water supply of Anderson Springs.

In the Occidental leasehold development, economic and practical considerations have resulted in decisions to allow encroachment on both Anderson and Gunning creeks by a road and drill pad which seemingly override technical and environmental precautions. Federal, state, and local agencies have recommended that drill pads not be sited closer to live streams than 250 to 700 feet.³⁷ Drill Pad B is located within 158 feet³⁸ of a perennial tributary to Gunning Creek. The Bureau of Land Management in the Five Tracts EAR³⁹ established a 400 foot riparian protection zone adjacent to Anderson Creek (map 24 in the EAR) in which no construction should be allowed. The proposed access road from drill site C to drill site B goes through this zone.

BLM established riparian nonencroachment zones with good reason. Increased sedimentation of streams attributable to road location and construction methods was clearly evident in a recent study of deposition in reservoirs in 48 Northern California watersheds.⁴⁰ Streamside roads produced twice as much sediment as roads located on ridges or slopes. The greatest sediment producers were improved secondary (gravel surface) roads located at streamside. Deposition increased 6.9 times for each mile of road per square mile of watershed above a reservoir (Anderson 1974). Road location is especially important in steep watersheds (Anderson 1976).⁴¹ If Occidental does not pave the access road berms and barrow pits over the route from drill site C to B, there is a strong possibility that erosion will increase and Anderson Creek will be degraded.

Investigators estimate that during construction, exposed soils erode 20 times faster than vegetated ones (NCPA-1979). According to the USGS⁴² the highest sediment rates occur during the first year after construction and decline rapidly during the following three or four years. Thereafter, rates decline slowly and remain above preconstruction level for several decades.

No attempt has been made to predict rates of gully erosion. However, a large gully exists along the south side of the old logging road from Aminoil's PDC No. 1 steam well to Drill Pad B. Precautions should be taken to divert runoff from the access road and Drill Pad B away from the existing gully.

SUSPENDED SEDIMENT TRANSPORT AND TURBIDITY

Various investigators (Fowler and Heady, 1981, and Robinson, 1971)^{43,44} characterize in-stream suspended sediment and bedload materials as the largest single polluting agent, by volume, in the United States. In their recent paper, Fowler and Heady concluded that suspended sediment loads are highest in the northwestern (which includes The Geysers KGRA) and southeastern regions of the United States. They further stated that these higher rates (greater than

0.25 tons per acre per year) relate to the steeper slopes, parent soil material, and the high rainfall and/or runoff prevalent in these regions. The rates suggest the need to exercise additional care during operations which disturb existing vegetation, soils, and terrain in these regions. Although they generally regard turbidity and suspended sediment as pollutants, investigators do not agree on the levels at which suspended sediment becomes detrimental. To limit turbidity in drinking water supplies, the State of California adopted a monthly average upper limit of one turbidity unit (NTU). For surface waters not exposed to significant sewage hazards or recreational uses, no consecutive two-day average may exceed five units.⁴⁵ These standards apply to water delivered to users, not raw water drawn from a well or surface stream. Appropriate treatment can bring raw water into compliance with these standards.

Currently no California standards exist for suspended or settleable solids for either human consumption or fish and wildlife habitats. Researchers have reached various conclusions concerning the detrimental effect of sediment in water bodies. As a result of their studies in California, Cordone and Kelley⁴⁶ characterized water containing 27 ppm suspended solids as "non-drinkable." Bean (1961)⁴⁷ proposed that for drinking water of ideal quality suspended matter should be limited to 0.1 ppm or less. A literature search by CEC did not reveal specific limits or threshold concentrations of settleable solids permitted in natural waters.

Various suspended solid thresholds have been determined for fish populations. Cordone and Kelley⁴⁸ found that in water containing 27 ppm sediment, the catch of fish dropped to one-half of normal, and the production dropped less than 10 percent although there was no increased mortality. Tests on the survival of rainbow trout in suspensions of inert solids (kaolin and diatomaceous earth) showed that concentrations of 30 ppm had no observable effect; a few fish died at 90 ppm, while at 270 ppm more than half of the fish died in 2 to 12 weeks.^{49,50}

The European Inland Fisheries Advisory Commission, Food and Agricultural Organization of the United Nations, prepared water quality criteria on finely divided solids.⁵¹ With respect to chemically inert solids and to waters that are otherwise satisfactory for the maintenance of freshwater fish, they made the following conclusions:

- "(a) There is no evidence that concentrations of suspended solids less than 25 ppm have any harmful effects on fisheries.
- (b) It should usually be possible to maintain good or moderate fisheries in waters which normally contain 25 to 80 ppm suspended solids. Other factors being equal, however, the yield of fish from such waters might be somewhat lower than those in category (a).
- (c) Waters normally containing from 80 to 400 ppm suspended solids are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower concentrations within this range."

Based on these and similar findings, fishery biologists have concluded that concentrations of suspended sediment less than 50 to 60 ppm will have little impact on fish and wildlife.

LEASEHOLD MITIGATION MEASURES

Federal, state, and local agencies require mitigation of impacts on water resources due to the development of roads, drill pads, and steam wells. When Oxy implements the mitigation measures, the potential for impact to local water resources should be lessened.

USGS MITIGATION REQUIREMENTS

Under authority granted them by the Geothermal Steam Act of 1970, the United States Geological Survey requires the following mitigation under terms of the federal lease granted to Occidental:

1. There shall be no construction or surface disturbance during the period from November 1 to March 1.
2. Any water needed for construction or maintenance of Site B and its road should be from a source authorized by the USGS and Bureau of Land Management (BLM), other than Anderson or Gunning Creeks.
3. The Anderson Creek crossing by the road from Drill Pad C to B shall be constructed according to California Department of Fish and Game recommendations.
4. No drill pad or sump runoff shall be discharged directly into Anderson or Gunning Creeks. Berms shall be constructed around the edges of pads to direct runoff into the sumps. Before sumps become full, excess water shall be pumped into tanker trucks and disposed of in an acceptable disposal area.
5. Subsurface groundwaters will be protected by casing and connecting procedures proposed in the Application to Drill (Form 9-331C) and approved by Office of Geothermal Supervisor, Menlo Park.

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD MITIGATION REQUIREMENTS

The Central Valley Regional Water Quality Control Board requires the following mitigation of impacts by Occidental under terms of Board Order No. 79-228 and its accessory Monitoring and Reporting Program:

1. Waste sumps shall be lined with at least 2 feet (0.6 m) of compacted clay or soil cement having a permeability of 1×10^{-6} cm/sec or less.
2. A minimum freeboard of three feet (one m) shall be maintained in the waste sumps.
3. Wastes produced during the drill site preparation, road construction, and road maintenance shall be placed where they cannot be carried into the waters of Anderson Creek, Gunning Creek, or their tributaries.

4. The disposal sumps shall be protected from any washout or erosion of waste or covering material and from inundation, which could occur as a result of floods having a predicted frequency of once in 100 years.

LAKE COUNTY MITIGATION REQUIREMENTS

Lake County under their permit authority requires the following mitigation:

1. Subdrains shall be provided under all fills where natural drainage courses and sewage are evident.
2. Berms should be constructed around drill pads, and all run-off from the pad surface should be directed into the sump.
3. Buffer zones of undisturbed vegetation shall (ordinarily) be maintained 500 feet on either side of streams. No geothermal related construction shall take place within this buffer zone without specific approval.
4. A retaining levee of not less than eighteen (18) inches in height and three (3) feet in base thickness shall be placed on the perimeter of all fill areas, including access road fills, pad site, and reserve pit sites, to prevent storm runoff accumulation from random discharge.
5. No water for construction purposes at Site B shall be removed from Anderson or Gunning Creeks, their tributaries, or springs in the area without first obtaining approval from the Anderson Springs Water Master and the USGS in consultation with the BLM and Lake County Planning Department.
6. Roads bridging or fording any water course or stream shall be surfaced at least 250 feet on either side of such crossing.

CEC MITIGATION/MONITORING REQUIREMENTS

In spite of Occidental's proposal to implement state-of-the-art erosion mitigation, there is still a strong likelihood that soils will be eroded from the leasehold and deposited in both Anderson and Gunning creeks. Deposition of soils in local creeks has the potential to physically and chemically degrade both the recreational and domestic water supplies of the community of Anderson Springs.

Historically, steam field developers and regulatory agencies have relied on empirical estimates for the determination of soil losses due to erosion, e.g., Universal Soil Loss Equation. Unfortunately, there is a paucity of actual data to verify the validity/credibility of such estimates.

Because of the lack of specific data for individual leaseholds it is difficult to determine whether an adverse impact has occurred, the magnitude of the impact, and its cause.

Therefore, CEC staff proposes that Oxy either:

1. Institute a network of continuous monitoring stations by November 1, 1981, to demonstrate the effectiveness of on-site mitigation, or

2. Mitigate the potential impact on the Anderson Springs water supply by replacing degraded water in quantity and quality.

The type of mitigation which would protect both Occidental and the downstream water users should incorporate the continuous monitoring of streamflow, turbidity, and sediment transport. The monitoring stations would be operated and the cross sections rated in accordance with techniques and methods described and in practice by the U.S. Geological Survey. The goal of operation would be to develop a flow and sediment discharge rating curve for the stations.

A suitable network of continuous monitoring stations would include the following:

1. On Anderson Creek below the crossing of the Occidental access road from drill site C to B.
2. On Gunning Creek below the Ford Flat Road crossing.

The proposed stations should include the following components:

1. An artificial, low flow control;
2. A stilling well and housing capable of enclosing the required recording devices;
3. A continuous water stage recorder;
4. A continuous turbidity monitoring device;
5. A continuous, pump type, sediment sampler;
6. An outside staff gage.

Other physical and chemical parameters would be monitored on an as needed basis.

JURISDICTION OVER WATER QUALITY CONTROL ISSUES

The California Water Code, Section 13,000 et seq., establishes a statewide program for water quality control that is administered regionally by nine regional boards, each within a defined area of jurisdiction. Water quality issues resulting from the Occidental project fall within the jurisdiction of the Central Valley Regional Water Quality Control Board.

Section 13241 of the Water Code requires the regional board to establish "such water quality objectives in water quality control plans as in its judgement will ensure the reasonable protection of beneficial uses and the prevention of nuisance". In addition to formulating appropriate water quality objectives for a regional water quality control plan, the regional board has the statutory obligation to prescribe requirements as to any proposed or existing discharge requirements; the regional board is required to consider a number of factors, including:

- (a) Past, present, and probable future beneficial uses of water,
- (b) Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area, and
- (c) Economic considerations. (See Water Code, Sections 13241 and 13263.)

An important aspect of the regional board's authority is described in Section 13267, which provides that a regional board, "in establishing or reviewing any water quality control plan or waste discharge requirements, or in connection with any action relating thereto or authorized by this division, may investigate the quality of any waters of the state within its region." This provision permits the regional board to conduct appropriate monitoring of an area's waters. In addition, Section 13267 authorizes the regional board to "require that any person discharging or proposing to discharge waste within its region...shall furnish, under penalty of perjury, such technical or monitoring program reports as the board may specify; provided that the burden, including costs, of such reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained therefrom."

Under this provision, the regional board has the authority to specify a monitoring program by the kind of technical report required of one responsible for a discharge. At the same time, however, the board has the responsibility of showing a reasonable relationship between the need for the report and the benefits to be obtained from it.

Because development of the steam field for the Occidental project is on a federal leasehold, that aspect is subject to the provisions of the federal Geothermal Steam Act of 1970 and federal regulations on the leasing of geothermal resources. With respect to water quality issues, the federal provisions complement state provisions in that a federal lessee is required to comply with "all federal and state standards and all applicable local

standards with respect to the control of all forms of...water...pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes." Moreover, the regulations adopted pursuant to the Geothermal Steam Act permit the Supervisor (who is under the direction of the United States Geological Survey) at his discretion, to "establish additional and more stringent standards." [See Title 43, Code of Federal Regulations, Section 3204.1(c)].

With respect to water pollution problems, the federal regulations specifically require a lessee to "conduct lease operations and maintenance in accordance with Federal and State water quality standards and public health and safety standards."

Accordingly, the applicant, although a federal lessee with respect to the steam field, is nevertheless subject to all applicable state laws concerning water quality control. Given the statutory authority of the Central Valley Regional Water Quality Control Board, the applicant is also subject to the discharge requirements, including an appropriate monitoring program, that the regional board shall in its analysis of existing and potential problems see fit to impose.

CUMULATIVE IMPACTS--BIOLOGICAL RESOURCES

SETTING

Earlier sections of this report describe the leasehold and Geysers KGRA (see Biology and Cumulative Environmental Analysis).

IMPACTS

THE OCCIDENTAL LEASEHOLD

Impacts on the Occidental leasehold are of a similar nature to those associated with construction of the power plant. Leasehold development will require approximately 59 acres of land now covered by native vegetation. The land requirements of well pads, steam lines, access roads, and transmission lines are compared with the power plant and its access road in Biology Table 3 (based on data supplied by Occidental Geothermal, Inc.). The vegetation types to be lost in this development are more diverse than that lost in the power plant itself.

CUMULATIVE ANALYSIS BIOLOGY TABLE 1

AREAS OF DISTURBANCE ASSOCIATED WITH STEAM FIELD DEVELOPMENT

<u>Item</u>	<u>Acres</u>	<u>Hectares</u>
Power Plant	18.5	7.37
Plant Access	.52	.21
Well Pads	15.63	6.31
Well Pad Access	6.18	2.50
Steam Lines	4.0	1.616
Transmission Lines	14.52	5.87
TOTAL	59.10	23.88

CEC staff does not expect any legally protected plants, species of special concern, or species of commercial importance to be impacted by the development of the steam field.

As with the power plant, concern for the loss of vegetation pertains mostly to impacts associated with soil erosion and wildlife populations. Losses will mostly be attributable to construction; however, small losses can be expected around venting steam wells due to release of phytotoxic substances. One access road (to well pad B) is being built on a relatively steep slope and crosses Anderson Creek. In addition, the northern most well pad (well pad B) is being constructed relatively close (within 160 feet) to Gunning Creek. Construction of these facilities, in addition to the power plant, steam lines, and other facilities on the leasehold, poses a serious threat to the Anderson Creek watershed (including Gunning Creek) through erosion of soil from denuded slopes. As described previously, sedimentation of these streams will likely result in serious impacts to aquatic biota (see Project Specific Impacts) and

to the Anderson Springs domestic water source, which is currently supplied by Gunning Creek (see Water Quality section).

Removal of vegetation will also have direct effect upon terrestrial wildlife through direct loss of habitat. Access roads and well pads will be constructed in areas which are distant from current development and which probably support substantial wildlife populations. The access road to well pad B will remove an area of riparian vegetation where it crosses Anderson Creek. Riparian vegetation is one of the most important wildlife habitat types on the leasehold due to the availability of water and numerous plant species which are valuable as food to wildlife. The U.S. Bureau of Land Management has recommended that riparian protection zones be established along both Anderson Creek and Gunning Creek and that no construction be allowed in these zones (BLM, 1978). The building of well pad B and its access road will occur within this zone and is therefore in conflict with sound biological resource planning. Construction of this well pad facility presents a threat of impacts to wildlife both on and off the leasehold (see U.S. Geological Survey, 1980, for comments from agency biologists concerning well pad B and its access road).

The loss of vegetation from steam field development is not expected to significantly impact either the endangered peregrine falcon or the fully protected golden eagle. Impacts on the fully protected ringtail are currently undefinable since adequate data are currently unavailable concerning this species on the leasehold. It should be noted, however, that riparian habitat, which this species prefers, is present and that the occurrence of ringtail on the leasehold seems very likely. It may be assumed that construction of these facilities will result in some currently undefined impact to the ringtail if it exists in this area.

Loss of recreational and other wildlife species can also be expected from development of the Occidental leasehold due to direct loss of habitat. However, if mitigated, these impacts should not be significant.

GEYSERS KGRA

CEC staff have examined cumulative impacts to terrestrial and aquatic biological resources in the steam dominated area of The Geysers KGRA (report in preparation). This report assesses biological impacts of three alternative development scenarios. The major findings of this report are summarized as follows.

Estimates of vegetation loss for existing power plants range from 500 acres to 1,607 acres. Depending on the ultimate development within the KGRA, total losses could vary from 1,860 acres to 3,720 acres over the next 20 years. As of 1979, about 247 acres of vegetation have been stressed and damaged due to cooling tower drift.

Vegetation loss eliminates habitat and food sources for wildlife. Wildlife studies conducted by PGandE (1977) indicate that there has been a shift in species composition in developed areas when compared with some undeveloped areas within the KGRA. The effect of increase in human activity in The Geysers has not been ascertained, nor have potentially beneficial effects of increased edge and vegetation patchiness.

Vegetation removal and construction activities have destabilized soil surfaces, accelerated erosion, and increased sedimentation of some KGRA streams. As mentioned earlier, studies in the KGRA have indicated that sedimentation has adversely affected trout populations.

MITIGATION MEASURES

Mitigation measures proposed for impacts to wildlife and aquatic biota are as follows:

- o Revegetation of disturbed surfaces with native species to encourage wildlife and species with good soil holding capability to discourage soil erosion.
- o Enhance wildlife habitat through vegetation management, including prescribed burns and hand clearing where necessary.
- o Monitoring of aquatic biological resources shall be conducted on Anderson Creek and Gunning Creek.
- o Monitoring of ringtail populations on the leasehold commencing as soon as possible to establish a population baseline to be compared with data collected during operations.

CUMULATIVE IMPACTS--AIR QUALITY

SETTING

CLIMATE

Moist air plumes from cooling towers generally disperse rapidly in the atmosphere due to their buoyancy, air entrainment, and atmospheric turbulence. Beyond a radius of about one-third mile (about one-half kilometer) from a particular cooling tower structure, the combined contribution from all operating cooling towers affects the environment (see Air Quality, Setting section).

The cumulative contribution of water vapor to the atmosphere from all power plants presently operating in The Geysers KGRA, in the absence of an intense inversion, results in only minor changes to the area's climate.

AIR QUALITY

Comparisons between the tracer tests and the model simulations focused on the model's capability to predict future incremental air quality effects from Oxy #1. These results indicate relative precision and accuracy of the model in predicting H₂S concentrations, especially peak values at sensitive receptor areas, due to emissions from a single-point source.

Oxy #1 will begin operation in 1984, when it will be one of several units operating at The Geysers KGRA. Therefore, it is necessary to determine the background air quality (to which Oxy #1 will contribute) in order to evaluate the overall or cumulative impact. As with the incremental impacts simulation, the cumulative effects prediction requires some form of evaluation to establish credibility and to use as a "yardstick" to compare model simulations against observed real-world concentrations.

Model Evaluation

In order to predict the 1984 worst-case ambient H₂S levels, a day (July 28, 1976) was selected during which H₂S standard violations occurred at sensitive receptors. The meteorological parameters and estimated emissions (see Cumulative Air Quality Table 1) for that day were used in the model simulation. Cumulative Air Quality Tables 2 and 3 summarize the observed and predicted H₂S concentrations at several locations for July 28, 1976.

The model appears to be relatively accurate in predicting background in sensitive receptor areas. For Geysers Rock (SRI-1) and Kahn Ranch (SRI-3) stations, the model generally underpredicts, while at sensitive receptor sites, such as Whispering Pines (SRI-5), Anderson Springs (SRI-6), and Sawmill Flat (SRI-7), there is relative agreement between predicted and observed concentrations. This agreement is better if model result one grid cell away from the station are compared to the observed levels.

Predicted 1984 Ambient H₂S Levels

Predicting ambient air quality in 1984 required the use of the worst-case meteorology (the July 28, 1976, meteorology data) and the expected emission

CUMULATIVE ANALYSIS
AIR QUALITY TABLE 1

ESTIMATED H₂S COOLING-TOWER EMISSION RATES
ON JULY 28, 1976

EMISSION SOURCE	AVERAGE HOURLY EMISSION RATES (lbs/hr)
PGandE UNIT #1	42
#2	44
#3	209
#4	192
#5	201
#6	315
#7	190
#8	119
#9	63
#10	63
#11	222
Wild Well	35
Total	1704 lbs/hr

Source: SAI 1981

CUMULATIVE ANALYSIS
AIR QUALITY TABLE 2
PEAK PREDICTED AND OBSERVED H₂S CONCENTRATIONS FOR SEVEN STATIONS*

Station Specific Values

Station	Maximum Hourly Equivalent H ₂ S Concentrations (ppb)		Average Error (percent)	Ratio of Predicted- to-Observed Maximum Concentrations
	Predicted	Observed		
Geyser Rock	49	120	-59%	0.41
Anderson Ridge	93	111	-16	0.84
Kahn Ranch	4	43	-91	0.09
Pine Summit	14	33	-58	0.42
Whispering Pines	35	41	-15	0.85
Anderson Springs	32	36	-11	0.89
Sawmill Flat	45	55	-18	0.82

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* The average error value is defined as follows:

$$\text{error} = \left(\frac{P - O}{O} \right) \times 100\%$$

† P - O = Predicted minus observed concentrations.

Source: SAI 1981

CUMULATIVE ANALYSIS
AIR QUALITY TABLE 3
1 Cell Radius

Station	Maximum Hourly Equivalent H ₂ S Concentrations (ppb)		Average Error (percent)	Ratio of Predicted- to-Observed Maximum Concentrations
	Predicted	Observed		
Geyser Rock	80	120	-33%	0.666
Anderson Ridge	98	111	-12	0.883
Kahn Ranch	9	43	-90	0.209
Pine Summit	30	33	-9	0.909
Whispering Pines	35	41	-15	0.854
Anderson Springs	40	36	+11	1.111
Sawmill Flat	51	55	-7	0.927

* The average error value is defined as follows:

$$\text{error} = \left(\frac{P - O}{O} \right) \times 100\%$$

† P - O = Predicted minus observed concentrations.

Source: SAI 1981

rates for PGandE units, the Department of Water Resources (DWR) units, Northern California Power Agency (NCPA) units, and the SMUD unit. The Northern Sonoma County Air Pollution Control Officer (NSCAPCO), in the SMUDGE0 #1 case, provided his estimate of the expected 1984 emissions from existing and proposed facilities (699 lbs H₂S/hr total; see Cumulative Air Quality Table 4). Since the SMUDGE0 case the NSCAPCO has revised his estimate of the expected emission rates (485 lbs H₂S/hr total; see Cumulative Air Quality Table 5). The CEC staff believes that the NSCAPCO revised estimates are valid for the 1985 - 1986 time frame, when PGandE is expected to retrofit existing Units 1, 2, 7, 8, 9, and 10 in accordance with the NSCAPCO Variance for these units (based on a comparison of the variance schedule, the revised NSCAPCO rules and the estimated emission rates).

Cumulative Air Quality Figures 1 and 2 show the predicted worst-case background H₂S concentration in the vicinity of sensitive receptors for the July 28, 1976, worst-case meteorology and the expected 1984 emissions (based on emissions shown in Cumulative Air Quality Table 4). The SAI simulation shows approximately a 24 ppb contribution from the NCPA units and the PGandE units. The DWR units will contribute approximately 0.1 ppb, and SMUDGE0 will contribute approximately 1.25 ppb (based upon a 5 lbs/hr emission rate). The predicted background level in 1984 is sufficiently close to 25 ppb (the ARB's criteria for determining a violation; see Air Quality Impacts section) that it is likely that a violation will occur in 1984 when Oxy #1 becomes operational.

Cumulative Air Quality Figure 3 shows the predicted worst-case background H₂S concentrations in the vicinity of sensitive receptors for the July 28, 1976, worst-case meteorology and the expected 1985 - 1986 emissions (based on emissions shown in Cumulative Air Quality Table 5). Results of this analysis would indicate that the background concentrations in 1985 - 1986 would be 10 to 15 ppb near Anderson Springs. These levels are sufficiently below 25 ppb that it is likely that a violation would not occur under normal operating conditions in 1985 - 1986 unless some unforeseen event occurs. The difference between the 1984 and the 1985 - 1986 background levels is due to the expected reduction in emissions from existing plants after 1984.

IMPACTS

CLIMATE

For the annual average wind speed of 15 miles per hour (SMUD meteorological station), the downwind contribution of water vapor is less than 0.1 gram per cubic meter of air at a distance of 5 to 10 miles (8 to 15 kilometers) from the operating units at The Geysers. At the coldest temperatures expected in the area saturated air could contain at least three grams of water vapor per cubic meter. This addition of water vapor corresponds to a change of less than 1°F in wet-bulb temperature readings.

During the dry season of April through October, the capacity of the air for water vapor ranges from 6 to 40 grams per cubic meter, so the addition of cooling tower water vapor from all units during this period will not change the wetbulb temperature more than 0.5°F. During this dry season, the area is

CUMULATIVE ANALYSIS

AIR QUALITY TABLE 4

1984 EMISSION LEVELS USED IN THE COMBINED IMPACT AIR QUALITY SIMULATION*

Unit	H ₂ S Emission Rate (lb/hr)
PG&E 1	60
PG&E 2	49
PG&E 3	20
PG&E 4	5
PG&E 5	22
PG&E 6	32
PG&E 7	24
PG&E 8	127
PG&E 9	63
PG&E 10	63
PG&E 11	37
PG&E 12	27
PG&E 13	11
PG&E 14	23
PG&E 15	12
PG&E 16	7
PG&E 17	26
PG&E 18	12
NCPA 1	13
NCPA 2	13
SMUDGE#1	8
DWR Bottle Rock	5
DWR South Geysers	5
Wild Well	<u>35</u>
Total	699

* Source: Estimates supplied by the Northern Sonoma
County Air Pollution Control District (July 1980).

CUMULATIVE ANALYSIS

AIR QUALITY TABLE 5

REFINED 1984 ^{**}HYDROGEN SULFIDE EMISSION ESTIMATES*

Unit	Uncontrolled (lb/hr)	Controlled (lb/hr)
PG&E 1	60	5
PG&E 2	50	6
PG&E 3	213	12
PG&E 4	161	12
PG&E 5	301	23
PG&E 6	426	23
PG&E 7	242	23
PG&E 8	126	63
PG&E 9	63	32
PG&E 10	63	32
PG&E 11	697	47
PG&E 12	204	47
PG&E 13	--	11
PG&E 14	85	23
PG&E 15	232	12
PG&E 16	--	5
PG&E 17	534	26
PG&E 18	202	12
SMUDGE#1--1	80	5
DWR Bottle Rock	280	5
NCPA 1	90	13
NCPA 2	90	13
Wild Well	<u>35</u>	<u>35</u>
Total	4234	485

* Source: Estimates supplied by the Northern Sonoma County Air Pollution Control District (January 1981).

** CEC Staff believes these levels are applicable in 1985-1986.

OXY GEOTHERMAL #1

Source: SAI (1980)

FIGURE 1: AIR QUALITY—Cumulative Analysis—Predicted 1984 Ground Level H_2S Concentrations Due to PG&E and NCPA-1 Emissions (ppb)

OXY GEOTHERMAL #1

Source: SAI (1980)

FIGURE 2: AIR QUALITY-Cumulative Analysis-Predicted 1984 Ground Level H_2S Concentration Due to DWR Bottlerock and South Geysers Emissions (ppt)

OXY GEOTHERMAL #1

Source: SAI (1980)

Between the hours of 1000 and 1100

**FIGURE 3: AIR QUALITY-Cumulative Analysis-Predicted 1985-1986
Ground H_2S Concentrations (ppb)**

generally in or above the inversion so that the relative humidity is low and the addition of cooling tower water vapor causes an insignificant change (CEC staff analysis, 1979).

However, one concern expressed by members of the scientific community is that even minor changes in temperature and humidity may impact sensitive plant species and their ability to survive (Neilson, 1975a; Ecoview 1975; Leitner, 1978). See Biological section of this EIR.

AIR QUALITY

Hydrogen Sulfide

The last step in determining compliance with ambient air quality standards is to add the worst-case predicted 1984 background H_2S concentrations at receptor areas and the incremental impacts of the Oxy #1 project. As described in the previous section, it is likely that a violation or near violation will occur in the Anderson Springs area when Oxy #1 comes on line. The incremental impact expected from Oxy #1 is between two and three ppb, in the same vicinity. Oxy #1's contribution, however, is not a measurable contribution as defined by the LCAPCD Rules.

By 1985 - 1986 the CEC staff expects the background levels in the receptor areas to be less (10 -15 ppb), provided PGandE meets the schedule of the NSCAPCO Variance. Under these conditions Oxy #1 will not cause the violation or contribute to a violation of the H_2S ambient air standard.

Particulates

Data collected regarding ambient TSP indicate no historical particulate ambient standard violations at sensitive receptors. Oxy #1, as proposed, is not a major source of TSP and is likely neither to contribute nor to cause a violation of the standard.

Assuming the TSP is transported to the same receptor areas as the H_2S emissions and assuming TSP impacts are proportional to their emission rate, an approximation of the expected ambient concentration is calculated below.

$$9.7 \text{ lbs } H_2S/hr = 2 \text{ ppb ambient concentration}$$

$$= 2.8 \text{ ug/m}^3 \text{ ambient concentration}$$

$$7.6 \text{ lbs TSP/hr} = 78\% H_2S \text{ ambient concentration}$$

$$= 2.2 \text{ ug/m}^3 \text{ ambient concentration}$$

The impact from Oxy #1 appears insignificant in comparison to the 100 ug/m^3 (24-hour average) ambient air quality standard for TSP.

Compliance During Abnormal Conditions

Analysis of project impacts must consider both anticipated emissions during regular operation (9.7 lbs H_2S /hr emission rate) and during abnormal conditions. A geothermal power plant periodically ceases operations due to either scheduled routine maintenance or because of an unscheduled forced shutdown. When this occurs at most power plants at The Geysers, the steam supply is vented directly to the atmosphere (unabated), referred to as "stacking." Oxy #1 will emit during stacking as much as 193 lbs H_2S /hr unabated (120 ppm $H_2S \times 1.61 \times 10^6$ lbs steam/hr = 193 lbs H_2S /hr).

The results of modeling and tracer analyses indicate that Oxy #1 emissions will result in a two to three ppb concentration contribution at Anderson Springs during normal operation. During stacking this contribution would increase approximately 20 times (193 lbs/9.7 lbs = 19.9). This would constitute a violation of the state AAQS for H_2S if stacking occurred during the worst-case meteorological conditions. Occidental proposed dual turbines and a turbine bypass system to mitigate this impact.

Prevention of Significant Deterioration (PSD)

Based on the SMUDGE #1 case, where the EPA determined a PSD permit was required, the Oxy #1 facility would require a PSD permit. Under PSD regulations (see Impact section description of PSD regulations), the maximum permissible deterioration in ambient particulate levels in a Class II area is 37 ug/m^3 (24-hour averaging time). Assuming the estimated particulate emission rate of approximately 7.6 lbs/hr, the expected maximum impacts from the project on ambient TSP are on the order of 2.2 ug/m^3 (averaged over 1 hour) at sensitive receptor areas. This impact would be even less if averaged over 24 hours as specified by the PSD Class II allowable deterioration increment. Consequently, the impact of the proposed Oxy #1 facility is far below the allowable Class II increment, and the facility is too far from the nearest Class I area to cause any significant air quality deterioration.

Based on previously approved PSD permits for geothermal power plants, the CEC staff expects the use of Stretford abatement supplemented by secondary condensate treatment to satisfy the federal BACT requirement.

MITIGATION MEASURES

The proposed mitigation measures for this project are identified in the Mitigation Measures section of the Air Quality Impact section. It is the CEC staff's opinion that no additional mitigation measures are required. However, the CEC staff emphasizes that the reliability of the proposed H_2S abatement technologies is critical to attaining and maintaining the ambient air quality standards for H_2S . The two violations of the AAQS at SRI-4 during the last year appear to be caused by concurrent stacking events. Since the Oxy #1 project would result in a violation of the AAQS for H_2S if the facility stacked during worst-case meteorological conditions, reliability of the controls is important. Occidental should ensure that sufficient capacity and redundancy for critical components are incorporated in the proposed facility design. Occidental should also ensure that the previously discussed corrosion problem (see Air Quality Impacts section) is adequately compensated.

CUMULATIVE IMPACTS--NOISE

SETTING

Other projects in the area of the proposed Oxy #1 project are PGandE Geysers Units 9 and 10, Unit 18, Unit 13, Unit 16 and SMUDGE #1 (see Noise Figure 1). The proposed Oxy #1 project is remote from these units and potential noise sensitive receptors. The other units in the Oxy #1 site area may raise the ambient noise level in receptor locations, such as Camp Verdant Vales and Anderson Springs. Because the Oxy #1 project is remote, it will not add to the impact of the other units.

IMPACTS AND MITIGATION MEASURES

The effects of the well development and steam field operation noise levels generally exceed the noise levels for plant construction and operation. These cumulative activities, however, will not increase the impact on the receptors beyond that caused by well development and well operation (see Project-Specific Impacts section). Therefore, the CEC staff concludes that no significant noise impact will result from the combined activities, and no measures to mitigate cumulative impacts are needed.

CUMULATIVE IMPACTS---WASTE

SETTING

Approximately 2,000 cubic yards of sludge per month are produced by existing power plants and are presently disposed of at a site near Middletown in Lake County. This sludge consists of waste from water processing systems at PGandE Geysers Units 3, 4, 5, 6, and 11 and waste from cooling tower basins at Units 1 - 11. Geothermal, Inc., owns this site, which they estimate to have a 50-year capacity to accept wastes at the current production rates. In addition, these wastes can be disposed of at IT Corporation's facilities (Kritikos, 1979; Simonsen, 1979; Central Valley RWQCB, 1979).

IMPACTS AND MITIGATION MEASURES

The Oxy Geothermal Plant No. 1's Stretford system will produce approximately 676 cubic yards of sulfur and used process solution per year; the H₂O₂ secondary abatement system may produce an additional 3.5 cubic yards of sludge per year. Disposing of these wastes will reduce the capacity of the waste disposal site, but if operators dispose of wastes properly, their adverse effects upon water quality and public health will be mitigated.

CUMULATIVE IMPACTS-HEALTH

SETTING

For discussion of overall setting, see introductory portion of Cumulative Environmental Analysis section.

Future development at The Geysers KGRA will increase the total quantity of pollutants emitted into the environment and will increase ambient pollutant concentrations locally and regionally. This project will contribute to the cumulative impacts of total geothermal development.

IMPACTS

REGULATED AIR POLLUTANTS

Hydrogen Sulfide

The Lake County APCD and Northern Sonoma County APCD have adopted regulations for retrofitting H₂S abatement at existing geothermal power plants which will reduce the potential cumulative impacts of H₂S emissions at The Geysers KGRA.

If the CAAQS for H₂S is enforced, the public should not be exposed to H₂S concentrations of 0.03 ppm or greater. However, existing hydrogen sulfide concentrations in populated areas near The Geysers KGRA occasionally exceed the standard with only 15 geothermal power plant units currently on line. Twenty units should be on line when the project begins operating. Unless compliance with the standard is enforced, even greater and more frequent violations could result from future development (see Air Quality Impacts section). Although experts do not know at this time if adverse health effects result from chronic exposure to low levels of H₂S, by inference, increasing H₂S concentrations will increase the possibility of adverse health impacts (see Appendix B-1).

Radon-222

If this project and future facilities comply with the California and federal radon-222 emission standards, the public should not be exposed to greater than a maximum 3 pCi/l of radon-222, or 1 pCi/l of radon-222 and its daughter products, above natural background radiation at the point of release. Oxy will monitor radon-222 concentrations in incoming steam to ensure compliance with these radon-222 standards.

A study conducted by Lawrence Livermore Laboratories (Anspaugh, 1978) concluded that the 11 units then operating at The Geysers power plant had "no discernible impact upon the radiological environment of the surrounding area. This is because the amount of radon-222 released by the operation of the power plant is small compared to the radon-222 exhaled from soil in the general area." Due to continued geothermal development since the Lawrence Livermore Laboratory study, CDHS Radiologic Health Section is beginning further cumulative impact studies of radon-222 emissions in The Geysers area.

NONREGULATED AIR POLLUTANTS (ammonia, arsenic, asbestos, benzene, silica, boron, mercury, ADA, and vanadium)

Operation of this project, existing and future power plant units at The Geysers KGRA will increase the concentrations of these pollutants in nearby populated areas. CEC staff can make crude estimates of potential cumulative impacts on ambient air concentrations of nonregulated pollutants at Anderson Springs, Whispering Pines, and other population centers from existing, CEC-approved, and currently proposed power plants, using results from H₂S studies. Table 5 lists the maximum predicted ambient air quality impacts of nonregulated pollutants from Oxy Geothermal Plant No. 1, SMUDGE #1, PGandE's Units 16 and 18, and NCPA #2. (No data are available for PGandE's Units 13 and 14.) The maximum cumulative impact is the sum of the maximum impacts from these facilities and background levels. Since the meteorological conditions producing the maximum impacts from each facility may not occur simultaneously, these values probably overestimate the cumulative impact.

Based on information in Cumulative Analysis--Health Table 1, ammonia, arsenic, and mercury concentrations might exceed the MEG ambient level goals. Even under worst-case conditions, available data indicates that ADA and vanadium would not exceed the MEGs. Due to incomplete data, cumulative concentrations of boron, benzene, asbestos, and silica cannot be meaningfully compared to the MEGs.

For the reasons stated in the Health Introduction and earlier in this section, predicted concentrations in excess of the MEGs or other suggested levels do not necessarily indicate that adverse health impacts will occur. CEC staff believe that failure to meet these goals demonstrate the need for monitoring emissions and ambient air nonregulated pollutant concentrations.

PUBLIC HEALTH IMPACTS FROM DRINKING WATER SUPPLY CONTAMINATION

Development of geothermal resources can lead to degradation of water quality in local creeks. The water quality setting section contains historical water pollution data reported for The Geysers KGRA. Degradation of creeks which supply drinking water may cause adverse public health impacts if contaminants are present in sufficient concentrations and duration. Appendix B-2 summarizes human health effects from consumption of water pollutants associated with geothermal development.

Facility design failure or human error and misjudgment may result in materials associated with geothermal development entering local creeks. Steam condensate containing toxic chemicals such as mercury and arsenic can spill into creeks if pipelines break or containment systems fail. Drilling wastes, cooling tower sludge, hydrogen sulfide abatement system wastes, and other toxic wastes (see Waste section), may enter creeks if sumps used to store wastes at the well pads fail or if trucks accidentally spill wastes in transport from the power plant to the disposal site. Trucking accidents could also release to the environment chemicals used to abate hydrogen sulfide emissions or other chemicals used on site. In addition, levels of suspended and settleable solids in creeks increase with erosion-causing activities such as earth moving.

CUMULATIVE ANALYSIS
HEALTH TABLE 1

CUMULATIVE IMPACTS OF NONREGULATED AIR POLLUTANT EMISSIONS

	Background Ambient Air Concentration ^a (ug/m ³)	Maximum Impact on Ambient Air Concentration ^a (ug/m ³)					Maximum Cumulative Impact ^g (ug/m ³)	Ambient Level Goal ^h (ug/m ³)
		Oxy Geothermal Plant No. 1 ^b	SMUDGE #1 ^c	PGandE Unit 16 ^d	PGandE Unit 18 ^e	NCPA #2 ^f		
Ammonia	1.4-7 ^k	15.9 - 39.75	4.8	247	30.0	0.008	328.6	43
Arsenic	0.001-0.0044 ^l	0.0019 - 0.0048	0.024	0.0024	0.000027	0.0005	0.034	0.005
Boron	<u>1</u>	0.48 - 1.2	0.74	0.096	5.05	0.45	7.54 ^j	7.4
Benzene	0.054	0.024 - 0.06	0.024	<u>1</u>	<u>1</u>	<u>1</u>	0.138 ^j	7.1 ^q
Mercury	0.001-0.018 ^m 0.005-0.4 ⁿ	0.0036 - 0.009	0.00012	0.033	0.0000072	0.0005	0.06- 0.44	0.1- 0.01 ^r
Silica	<u>1</u>	0.034 - 0.084	0.6	31.38	<u>1</u>	<u>1</u>	32.06 ^j	-
Anthraquinone Disulfonic Acid	<u>1</u>	0.0231 - 0.058	0.0006	0.003	0.0016	0.00015	0.062	260
Vanadium	0.005-0.024 ^p	0.015 - 0.0375	0.0012	0.006	0.0033	0.00029	0.071	1.2

Footnotes and References for Cumulative Analysis--Health Table 1

- a. Expressed as annual average; obtained by multiplying hourly average by 0.1 (see Appendix C).
- b. Oxy Geothermal Plant No. 1 Draft EIR Impacts Section Table 4.
- c. SMUDGE0 #1 Final EIR, Table 21.
- d. PGandE Geysers Unit 16 Final EIR, Table 18.
- e. PGandE Geysers Unit 18 Final EIR, Table 13.
- f. NCPA No. 2 Final Joint Environmental Study, pages IV-58 to IV-61.
- g. These values are the sum of the maximum ambient air quality impacts calculated for Oxy Geothermal Plant No. 1, DWR South Geysers Power Plant, PGandE's Units 16 and 18, NCPA #2, and maximum background levels. Impacts from PGandE's units 13 and 14 are not included due to lack of data. It assumes that the maximum air quality impact from the five facilities could occur simultaneously at one location. The maximum ambient air quality impact from each facility occurs under different meteorological conditions, and are not expected to occur simultaneously. Therefore these values probably overestimate the cumulative impact.
- h. Estimated permissible concentration (annual average) in air; toxicity based on health effects (EPA, 1977).
- i. No data available.
- j. Based on incomplete data.
- k. Measurements of urban air concentrations (Wagoner, 1976).
- l. Measured near Unit 11 (PGandE, 1979).
- m. Particulate mercury measurements in Geysers KGRA (Robertson, 1977).
- n. Vaporous mercury measurements in Geysers KGRA (Jepsen, 1973).
- o. Measurements of rural air concentrations (Wagoner, 1976).
- p. Estimated permissible concentration (annual average) in air; toxicity based on genotoxic effects would be no more than 0.7 ug/m^3 , in accordance with the NIOSH recommended occupational level of 1 ppm (EPA, 1977).
- q. Estimated permissible concentration (annual average) in air; toxicity of zero-threshold pollutants based on genotoxic effects (EPA, 1977).

The potential for adverse human health impacts from consumption of polluted drinking water depends on (1) toxicity of the contaminants (2) concentration or quantity to which the public is exposed, (3) duration of exposure, and (4) the ability of existing waste water treatment facilities to remove pollutants. Concentration, duration of exposure, and degree of pollutant removal by the treatment facility vary with the water pollution incident, and this prevents CEC staff from predicting the magnitude of potential public health impacts. Since state and federal drinking water standards are based at least in part on human health protection, routine compliance with these standards should adequately protect public health. However, Oxy should perform appropriate mitigation measures to ensure compliance with standards and to maximize prevention of accidents and design failures in watersheds which furnish domestic water supplies (see Water Quality Mitigation Measures section and Transportation Mitigation Measures section).

MITIGATION MEASURES

Oxy could achieve mitigation of potentially adverse health effects from exposure to geothermal pollutants by reducing air pollutant emissions where possible (methods of H₂S abatement are discussed in the Air Quality Impact section). There are no demonstrated technologies for abating emissions of radon-222 or other nonregulated geothermal power plant pollutants specifically, although H₂S abatement systems, particularly upstream treatment, may scrub pollutants other than H₂S to some degree (Accurex, 1980).

The Water Quality section addresses measures to mitigate impacts to drinking water quality. These mitigation measures should also reduce the potential for adverse health impacts related to drinking degraded water.

HEALTH RELATED MONITORING PROGRAMS

Monitoring alone does not mitigate any potential public health impacts; rather, it assists in determining the magnitude of project impacts, and those of geothermal development in general, on ambient pollutant concentrations and ultimately on public health.

DHS, in cooperation with EPA, plans field and source sampling for radon-222 and its daughter products in The Geysers KGRA. These efforts represent an attempt to minimize uncertainty in anticipating the total impact on human radiation exposure associated with the operating Geysers units (Vold, 1980).

CEC staff is examining the feasibility of conducting a program for 1981 - 1982 assessing the health status of Geysers KGRA residents.

CEC staff suggests that Oxy establish a baseline ambient air monitoring and incoming steam monitoring program based upon the following:

- o Available data on background air concentrations of nonregulated pollutants are outdated and inadequate for use in determining resultant concentrations in populated areas.

- o Ongoing and future development will increase pollutant emissions at The Geysers during the operating lifetime of this project.

CEC staff further recommends that Oxy conduct the following monitoring programs:

- o Ambient monitoring for ammonia, arsenic, benzene, mercury, silica, and vanadium for one year prior to and one year after commencement of the project operation.
- o Incoming steam monitoring (operational) for ammonia, arsenic, benzene, mercury, silica, boron, and radon-222.
- o Mass balance measurements (operational) for arsenic and mercury.

The Water Quality section addresses water quality monitoring in creeks which supply drinking and recreational waters. In addition, CEC staff recommends that during power plant operation, Oxy monitor potentially toxic constituents in Gunning Creek, which supplies drinking water for Anderson Springs.

For two years after commencement of power plant operation, Occidental should monitor quarterly in Gunning Creek downstream of the project area the constituents listed in the proposed Brown and Caldwell water quality monitoring program (May 1981) plus arsenic, mercury, chromium, vanadium, oil and grease, and gross alpha and beta radioactivity. Upon agreement by Oxy and CEC, Oxy need not conduct independent monitoring if the ARM program includes monitoring these contaminants at appropriate times and locations. Oxy should not be required to conduct the monitoring if water quality protection measures, such as enclosing the Anderson Springs water supply, are undertaken.

In addition, CEC staff recommends that Occidental monitor water in Gunning Creek downstream of the project area for asbestos once during power plant construction and once during peak runoff conditions after the power plant is operational. Occidental should use sampling methods recommended at the time by the California Department of Health Services (CDHS), Air and Industrial Hygiene Laboratory (AIHL), and have the analysis conducted by a CDHS/AIHL approved laboratory. Oxy would not be required to conduct this monitoring if measures to protect drinking water sources, such as enclosing the Anderson Springs water supply, are performed.

These programs will be described in the Compliance Monitoring Report to be developed by CEC staff and Occidental Geothermal, Inc., during AFC proceedings for this project.

CUMULATIVE IMPACTS-TRANSPORTATION

SETTING

The Occidental project is part of ongoing geothermal development in The Geysers KGRA which includes existing PGandE units 1 through 15. The same transportation network used by the Oxy project is used to one degree or another by most of the existing and planned developments in The Geysers. Projects which are presently under construction or which may overlap with the Oxy project are as follows: PGandE Units 17 and 18, NCPA #2, DWR Bottle Rock, and SMUDGE #1 are under construction; PGandE Unit 16, and DWR South Geysers may be under construction. Other projects which are planned, but which have not yet entered the AFC process, are NCPA 1 and 3 and PGandE Unit 20. Several other projects may overlap in the final stages of Oxy construction. For information on the status of these projects, see introductory section on Cumulative Analysis regarding current and anticipated geothermal development.

IMPACTS

The construction of Oxy #1 is expected to start April 1982 and continue through May 1984. During this period there will probably be 7 or 8 other geothermal projects under different phases of construction and some 15 plants under commercial operation within the KGRA region. Four of the plants likely to be under construction (PGandE 16, 18, SMUDGE #1, NCPA 2) are in the same general area as Oxy and can be expected to impact the same roads. In addition to the impacts caused by plant construction traffic, one must also consider the impact of truck and general traffic associated with steam field development. The other projects which may be under construction (PGandE 17, DWR Bottle Rock and South Geysers, and possibly NCPA 1) will contribute to traffic and truck impacts on the roads in the wider Geysers region.

The cumulative work force will peak at about 950 workers (steam field, plant construction, and operation and maintenance) around 1982 and steadily decrease to about 450 at end of 1984.

The CEC staff estimates an average of 30 to 40 heavy trucks per day traveling The Geysers region. As the development and traffic volume in The Geysers area increases, so do the travel hazards on the roads in this area. For 1979, CalTrans estimates the daily traffic average on Highway 175 to be 800 (CALTRANS, Office of Traffic Engineering), and a 1980 estimate of traffic on Socrates Mine Road is 684 vehicles per day (Lake County, 1980). Traffic volume data on other Geysers roads is not available at this time.

The extent or significance of road deterioration resulting from heavy equipment traffic due to this project cannot be accurately assessed. However, the increasing number of geothermal power plants in The Geysers KGRA results in increased heavy equipment traffic associated with construction and operation activities. This traffic results in a significant cumulative effect of accelerated deterioration of the private and public roads in Lake and Sonoma counties which serve the geothermal area.

MITIGATION

The potential number of vehicles which may travel in The Geysers is quite high. To decrease the number of vehicles traveling within The Geysers area, the construction personnel will be bused to work, and ride-sharing for smaller work forces will be encouraged. Oxy will participate in efforts to improve Socrates Mine Road which should alleviate some of the traffic problems experienced as a result of geothermal development.

SOCIOECONOMICS

SETTING

The Geysers Known Geothermal Resource Area is located in portions of Lake, Mendocino, Napa, and Sonoma counties. While the proposed power plant and associated facilities are in Lake County, geothermal development primarily has taken place in Sonoma County. As more of the KGRA develops, however, CEC staff expects more geothermal activity to occur in Lake County. Since geothermal activities and their resulting impacts have concentrated within these two counties, the impact discussion will emphasize Lake and Sonoma counties.

The four counties that comprise The Geysers KGRA have all undergone rapid growth over the past decade, and CEC staff expects this growth to continue well into the future. In-migration is the predominant growth factor for all four counties, which condition is most likely due to their rural characteristics.

Sonoma County, the largest and most urbanized of the four counties, had a total population of 292,275 in January 1980 (California Department of Finance, 1981). This growth represents a 42 percent increase over the 1970 population. Much of this growth centered in the incorporated communities of the south.

Those communities adjacent to the KGRA in Sonoma County have not kept pace with the countywide growth rate. The largest community, Healdsburg, 15 miles southwest of the proposed project, has a population of 7,137, a 31 percent increase over the past decade. Other Sonoma County communities adjacent to the KGRA are small, with populations less than 3,000.

Lake County, with a total population of 35,000 in January 1980 has one of the highest growth rates in the state over the last decade--89 percent (California Department of Finance, 1981). This growth is entirely due to in-migration, mainly of elderly retirees, and balances evenly between urban and rural areas. This influx of older people gives Lake County the highest median age of any county in the state.

Lake County contains many communities which are adjacent to the KGRA. Middletown, located 8 miles to the southeast of the proposed Occidental site, has an approximate population of 1,500. Anderson Springs and Whispering Pines are the two closest Lake County communities to the proposed site, with an estimated permanent population of 200 people and 145 people, respectively. This portion of Lake County has not experienced the high median age common in the rest of the county. CEC staff attributes growth in this area mainly to the influx of geothermal workers.

Mendocino and Napa counties, with populations of 66,751 and 97,361, respectively, have also grown rapidly. Much of Mendocino's growth occurred in rural areas, while Napa's has concentrated more in the incorporated communities.

Although agriculture is still the leading industry for the region, its importance is declining, while recreation, construction, and mining (including

geothermal activities) are on the increase. This is especially true in Sonoma County, which has greatly expanded its service, retail, and industrial sectors.

Government and retail trade sectors are the largest employers in the four county area; the one exception is Mendocino, where the manufacturing sector has the largest number of employees. Employment in agriculture is generally understated due to the large percentage of self-employment.

The fact that the region's economy relies on agriculture creates a demand for seasonal, unskilled labor. Lake County, for example, has an unemployment rate well above the statewide average due to the large percentage of seasonally employed workers. Sonoma County, on the other hand, is the exception within the region, with a declining unemployment rate due to the diverse economic base.

IMPACTS

CEC staff anticipates employment opportunities and the resulting impacts upon population, housing, and public services to result from the proposed project as well as from the cumulative impacts from other geothermal activity. While the proposed project is located in Lake County, project-specific and cumulative impacts will occur in Sonoma County and, to a much lesser degree, Mendocino and Napa counties as well. Specific levels of impacts which staff anticipates to occur within each county are discussed below.

EMPLOYMENT

Most of the employment impacts associated with the development of the proposed Occidental #1 power plant will occur during the construction phase of the project. Oxy plans to begin construction of the power plant in April 1982, employing a peak construction force of 230 workers. Once Oxy completes construction, operation and maintenance of the facility will only require four employees.

The development schedule in the KGRA has provided an effective staggering of employment activity, which allows many employees to work on several projects on a sequential basis. Thus, new geothermal projects, such as the proposed Occidental development, do not directly translate into new employment opportunities for those workers outside the current four county labor pool.

Although the proposed Occidental project is one of three developments scheduled to begin construction in FY 82, extensive use of the existing labor pool will still be possible. Additionally, since this is during the peak employment period (see Socioeconomics Figure 1), the net impacts from those projects prior to and subsequent to the Occidental development will overshadow any project-specific impacts resulting from this development.

As shown in Figure 1, peak employment for all phases of steam field development, power plant construction, and operation will occur within the period 1981 - 1984. Besides the proposed Occidental project, this anticipated cumulative workforce assumes all other facilities that are currently proposed will be built (assumed cumulative capacity of 1,731 megawatts) on schedule. These would include DWR's Bottle Rock and South Geysers, PGandE's 16, 17, and 18, SMUDGE #1, and NCPA's 1, 2, and 3.

OXY GEOTHERMAL #1

FIGURE 1: SOCIOECONOMICS-Cumulative Development Workforce/the Geysers KGRA

Since the Occidental project is part of the peak period of geothermal development, the following discussion reviews the cumulative impacts of development in The Geysers. The estimated cumulative labor demand for 1983 will be 948 workers. This figure includes all 3 phases of geothermal development and is an increase of 446 workers over the previous labor peak in 1978 of 502 (this includes steam drillers and operation and maintenance crews).

Based upon this figure and the following assumptions, it is possible to derive an estimate of the number of new residents for each county generated by geothermal development.

- o All of the approximately 300 workers that were employed during the 1978 peak construction period still reside in the 4 county area (Lake, Mendocino, Napa, and Sonoma) and are available for employment for geothermal development. Those living in each county will not move to another county because of a specific project.
- o Of the 446 new workers, 40 percent of 178 nongeothermal workers with the necessary skills already reside in the 4 county area and are willing to commute to a given project site. As existing residents, their employment will not represent a population increase nor will they cause an increase in induced employment. CEC staff obtained the 40 percent figure from a study entitled Construction Worker Profile (Mountain West Research, Inc., 1975). This study derived the 40 percent figure from a survey of 14 energy projects. Staff feels that this is a reasonable estimate as evidenced by unemployment trends within the four county area.
- o Of the remaining 268 workers, it is estimated that 50 percent will reside in Sonoma County, 40 percent in Lake County, and 5 percent in Mendocino and Napa counties each.
- o Based on data in the Construction Worker Profile study, 50 percent of the workers moving into the 4 county area will bring families, and each average family will consist of a spouse and 1.5 children.

Using these assumptions, staff estimated the following figures for new residents within the 4 county area due to geothermal development.

	<u>Sonoma</u>	<u>Lake</u>	<u>Napa</u>	<u>Mendocino</u>	<u>Total</u>
Single Workers	67	54	7	7	135
Workers with Families	67	54	7	7	135
Spouses	67	54	7	7	135
Children	<u>100</u>	<u>80</u>	<u>10</u>	<u>10</u>	<u>200</u>
Total New Residents*	301	242	31	31	605

*These numbers have been rounded up and are therefore a little high.

According to these figures, during the peak period the estimated total population increases in the 4 counties from the cumulative effect of geothermal development in the KGRA will be an additional population of 605 people, 200 of them children. (See Socioeconomics Figure #1.)

Increased employment in geothermal development may also generate employment in other sectors of the local economy through the increased demand for services. Since the major employment phase of The Geysers development is temporary, however, staff expects these induced job opportunities to be limited. Additionally, the high unemployment rate for the area, resulting from the seasonal employment patterns of agriculture and the large tourist serving industry, provides a large pool of workers which may be assumed to fill these geothermal induced positions. This will further reduce the likelihood that these induced employment opportunities will attract new residents into the four county area.

The level of new, direct, and induced employment represents only a small addition to each county's labor supply; therefore, further geothermal development, including the Oxy project, will not have an adverse significant impact on the labor supply in the four county area. However, geothermal development may provide increased employment to the local labor force.

HOUSING

All four counties within the KGRA report an increased demand for housing in order to meet population pressures and to replace currently substandard housing. Preliminary 1980 census data indicates actual housing availability is quite limited. The data shows Mendocino's overall vacancy rate is 7.3 percent; Napa's and Sonoma's average 9.5 percent, while Lake's rates are over 20 percent. Actual vacancy rates are much lower due to the large percentage of seasonally occupied second homes that are counted as vacant units. The Sonoma County Housing and Community Development Office undertook a condominium conversion study for the city of Healdsburg which indicates a vacancy rate of less than 2 percent (Christine Gouig, personal communication). The community of Calistoga in Napa County reports a similar vacancy rate. These rates are well below a desirable level and result from many factors, including geothermal development. Therefore, in an impacted housing market, additional demand must be considered a significantly adverse effect. However, based upon the nature of transient workers' housing demand and the large distance which workers commute (for example, Ukiah, a round trip of 70 miles each day), the housing requirements resulting from geothermal development will disperse over a large area and reduce the significance of this impact. Because of existing bus transportation new residents will have a large area to choose from within the housing market.

Based upon the cumulative employment impacts discussed above, staff estimates a worst-case housing demand for each county.

<u>Sonoma</u>	<u>Lake</u>	<u>Mendocino</u>	<u>Napa</u>
134	108	14	14

This assumes single workers as well as workers with families will occupy a single dwelling unit each. Based upon the overall growth experienced by each county, the countywide impacts on housing will be significant.

Geothermal workers have used resort rental units in Lake County, but such rentals are difficult to obtain during the summer season. CEC staff expects

those employees necessary for the operation and maintenance of the proposed project to locate in communities adjacent to the KGRA. However, their numbers are too small to have an impact on the local housing market.

In conclusion, staff feels there will be a temporary adverse impact on housing within the four county area, especially Lake and Sonoma counties. The availability and location of dwelling units for the transitory construction workers will determine the significance of this impact. Based upon the distances presently traveled by many workers, these new residents will be dispersed over the four county region, greatly reducing the significance of any impacts on an individual community.

EDUCATION INSTITUTIONS

Due to the rapid growth rate in Lake County in recent years, several school districts have experienced a sharp increase in the number of new students, mainly of elementary school age. Of the seven Lake County school districts, three districts--Kelseyville, Konocti, and Middletown--are operating at or near capacity.

The Middletown Unified School District undertook a survey which showed that one-third of the students in the district have parents who are employed in geothermal or related occupations (Bill Cornelison, December 1980). This district may be the worst impacted within the four county area because of the high numbers of geothermal workers locating in the Middletown area due to its proximity to the KGRA. PGandE estimates that between 25 and 50 percent of those geothermal workers living in Lake County reside in the Middletown-Cobb Mountain Area (PGandE, 1981).

On the other hand, Sonoma County School Districts have reported declining enrollments since 1977. Since most of the existing power plants are located in Sonoma County, the Geyserville and Cloverdale School Districts have benefited from geothermal development as a result of increased tax revenues and total assessed valuation (Vollintine et al., 1977). With the passage of Proposition 13, school financing does not rely on local property taxes but now comes directly from the state. State funding of schools, however, is in a state of flux due to current budget reductions. Thus, further funding for impacted Lake County School Districts may not be sufficient to meet their needs.

MITIGATION MEASURES

Under Assembly Bill 1905 (Bosco), a portion of the monies generated from the lease of federally owned geothermal lands is dispersed to the county of origin through the state. School districts may apply for these monies to aid schools impacted by geothermal development. To date, the Middletown and Konocti School Districts have received a total of \$50,000 from the Lake County Board of Supervisors in 1905 monies. CEC staff requires no mitigation measures of Occidental.

PUBLIC SERVICES

SETTING

For information on the setting for public services, refer to socioeconomics setting.

IMPACTS

Project-specific impacts on most public services from the proposed Occidental geothermal development will be insignificant. Since the facility will be located in Lake County, on-site fire and police protection will be provided by the California Department of Forestry, the Middletown Volunteer Fire Department, and the Lake County Sheriff's Department. Hospitals in either Santa Rosa or Clear Lake Highlands will provide medical services. Sewage disposal will be on site. Oxy will truck in bottled water for human consumption while cooling tower condensate will meet most other water needs. While the incremental increase of the proposed facility on these public services, especially police, fire, and medical services, are insignificant, the cumulative impacts of geothermal development cause greater concern.

One significant project-specific impact on public services will be the deterioration of the Anderson/Gunning Creek watershed, which provides both recreational and domestic water for the community of Anderson Springs. Degradation of Gunning Creek would require improvements to this private water company's supply system and result in fiscal impacts to the community. (For further discussion please see Water Quality section.)

Of additional concern are the cumulative impacts to local jurisdictions which must provide public services to accommodate the population growth resulting from geothermal development. Staff estimates these impacts will be insignificant due to the dispersal of new geothermal related residents throughout the four county area. CEC staff anticipates that impacts will occur in Lake County, where the existing infrastructure has been stressed to accommodate the drastic growth in recent years.

MITIGATION MEASURES

The Lake County Board of Supervisors administers monies provided under AB 1905 (Bosco) which has been used to identify and mitigate geothermal impacts, although the privately owned Anderson Springs Water Company is not eligible for 1905 money. No mitigation measures are required of Occidental except for those pertaining to the watershed (see Water Quality section).

FISCAL IMPACTS

Local economies receive direct and indirect fiscal benefits from geothermal development. These benefits include an approximate \$678,000 paid to Lake County from property taxes on the proposed project the first year alone (Occidental AFC, 1981). The purchase of materials and employee spending within the four county area will also provide sales tax monies.

For Sonoma County, staff estimates that geothermal development comprises 7 percent of the total county economic base taxes, while for Lake County this figure is 12 percent. Since future geothermal development will occur increasingly in Lake County, this figure could become much higher.

Negative fiscal impacts of geothermal development are difficult to predict or quantify. These may include increased demand for public services. However, the four counties have experienced rapid population growth which is unrelated to geothermal development; thus, it overshadows those impacts directly related to geothermal activities. Staff anticipates that negative fiscal impacts to Sonoma and Lake counties from the proposed project and the cumulative development of geothermal resources will be insignificant compared to the positive fiscal benefits coming from property and sales taxes.

IV. UNAVOIDABLE SIGNIFICANT ADVERSE ENVIRONMENTAL EFFECTS

EFFECTS SIGNIFICANT DESPITE MITIGATION

For project impacts judged to be significant unless mitigated, this section summarizes adverse effects remaining after implementation of all proposed mitigation measures. This summary includes those impacts which would be significant as well as those rendered insignificant through effective mitigation. For more thorough discussion of each topic, refer to the specific section of the Environmental Analysis chapters of this EIR.

GEOLOGY

Earthquake Shaking

There may be an increase in microseismic activity due to the presence of a geothermal power plant; however, accurate predictions regarding such activity are not possible. Not enough is known about the phenomenon as related to geothermal power plants. However, it is anticipated that such microseismic activity will not have far-reaching effects. Some degree of subsidence is expected due to reduction of the geothermal steam reservoir.

Compliance with design criteria will reduce the risk of earthquake-induced structural damage to an acceptable level.

Landslide and Slope Stability

Proposed design and construction methods combined with the site-specific geology would probably reduce the hazard to insignificance.

Differential Settlement

Proposed design and construction methods would reduce the hazard to insignificance.

SOILS

Power Plant Site

Construction of cut and fill slopes connected with the power plant site will result in increased sediment deposition and transport into Anderson Creek. Erosion may persist in the vicinity of culverts, cuts, and fills. Once Oxy completes construction and applies mitigation measures, CEC staff expects it will take three years for the area to stabilize and return to new pre-construction rates.

Transmission Corridor

To develop the preferred transmission route, Oxy will disturb the soil mantle on approximately 13 acres. CEC staff expects some erosion from this disturbance to occur, although it is not seen as significant.

Leasehold

Full leasehold development will remove the existing vegetative cover and disturb or remove the soil mantle from 50 - 60 acres of the 550 acre Occidental parcel. Thirty-seven of the acres lie in the Anderson Creek watershed, or about 8 percent of the watershed area enclosed within the leasehold. An increase in erosion from denuded slopes and deposition of additional sediment in Anderson and Gunning creeks is inevitable as a result of the proposed disturbance.

HYDROLOGY/WATER QUALITY

Power Plant Site

Construction of cut and fill slopes connected with the power plant site will result in increased sediment deposition and transportation in Anderson Creek. An unavoidable consequence will be water quality degradation, particularly during intense rainstorms typical of The Geysers KGRA.

Excavation and fill placement for the sediment basin will disrupt and alter the flow from a spring on the 3,400 foot contour. Fill placed in the intermittent tributary of Anderson Creek will change both surface and groundwater flow patterns, although the impact will be small and localized.

Leasehold

See comments under SOILS (Leasehold) above. Various regulatory agencies (CEC, Lake County, USGS, BLM, CVRWQCB) are working with Oxy to ensure that degradation to recreational and domestic water sources are kept to a minimum. Nevertheless there will be impacts. Oxy proposes full leasehold development despite environmental documentation indicating the sensitivity of placing a geothermal development at the top of a relatively fragile watershed, which provides both potable and recreational waters to downstream users.

BIOLOGY

Vegetation

Construction of the power plant, access road, and transmission line will remove about 21 acres of vegetation. Full leasehold development will disturb from 50 - 60 acres and reduce various vegetation types. Although CEC does not expect these losses to directly impact any legally protected species, species of special concern, or species of commercial importance, Oxy has not yet completed adequate studies on the occurrence of rare plants, so staff's conclusions are tentative.

Wildlife

As explained under the Soils and Hydrology/Water Quality section of the EIR, sediment entering local streams could result in serious impacts to aquatic biota, which include (among others) the recreational species, rainbow trout.

Should a toxic spill occur and enter the creeks, it could will fish and other forms of aquatic life. Safe handling of toxic materials as well as various

power plant and steamfield design features should reduce this possibility to a minimum.

The loss of vegetation due to Oxy's full project will reduce habitat for a number of wildlife species; however, if mitigated, these impacts should not be significant. The one fully protected species which Oxy's development may affect is the ringtail. This small raccoonlike creature frequents riparian zones. Although CEC staff considers the Oxy leasehold likely to contain ringtail, the impacts to this fully protected species cannot be assessed due to lack of data concerning their existence on the leasehold.

The riparian habitat is of particular value to wildlife in the area because it provides them with a source of water. Oxy's access road within the leasehold as well as their drill Pad B both encroach on the riparian protection zone recommended by BLM in the 1978 5-Tract EAR. Oxy's placement of drill Pad B within 160 feet of Gunning Creek encroaches on the setback distances recommended by the following agencies in response to the 1980 Draft Environmental Assessment by UGSG: California Department of Fish and Game, U.S. Fish and Wildlife Service, and Lake County.

AIR QUALITY

CEC staff anticipates the Lake County Air Pollution Control Officer (LCAPCO) will issue a Determination of Compliance (DOC) for Oxy #1 which indicates that the project will contribute incrementally to an existing violation of the California Ambient Air Quality Standards (CAAQS). To achieve compliance, and under rule 608, the APCO will probably require Oxy to limit their H₂S emissions to eight lbs/hr. Oxy will employ best available control technology (BACT) to reduce their emissions accordingly; however, even if they could reduce their emissions to zero, it would not eliminate the probability of violations occurring in the KGRA. Factors contributing to the air quality violation are cumulative in nature, with existing power plants contributing heavily. The main point, in terms of environmental consequence, is that air quality in The Geysers is reaching the point of impending violation. Oxy #1 will contribute incrementally to this violation, but on a very small scale.

Small quantities of potentially deleterious substances contained in geothermal steam may be carried in the cooling tower plume, lifted into the air, and deposited on soils, vegetation, wildlife, and populated areas. The effects of small concentrations and cumulative deposition of substances such as radon, mercury, arsenic, and boron are not sufficiently understood, and the significance of the impacts is unknown. The use of BACT, mentioned above, will reduce these emissions considerably; nevertheless, small amounts will be deposited on the local environment as a result of Oxy Geothermal #1.

NOISE

If Oxy implements all proposed mitigation measures, operation of the power plant will not result in significant noise impact.

Sensitive receptors near the steam field may hear such activities as production testing, unmuffled well venting, and wellhead master valve changes. These activities occur infrequently and can be restricted to daylight hours.

Construction traffic along access routes to the leasehold may subject people along the route to intermittent noise levels which exceed the nighttime standard of the Lake County draft noise ordinance. If Oxy limits heavy truck traffic to daylight hours, staff believes their impacts will be insignificant.

WASTE MANAGEMENT

Provided Oxy stores and disposes of wastes according to regulation, CEC anticipates no adverse impact from hazardous wastes.

HEALTH

The project will contribute, albeit in a relatively small amount, to existing violations of the California Ambient Air Quality Standard for H_2S . Although experts do not know at this time if adverse health effects result from exposure to low levels of H_2S , the inference is that increasing H_2S concentrations will increase the possibility of public odor complaints as well as the possibility for adverse health impacts in The Geysers area. In addition, the project's emissions of nonregulated pollutants, combined with other power plant emissions, increase the possibility of adverse health impacts from these pollutants. With only scarce data on steam quality, actual emission rates, and transport of nonregulated pollutants, comparisons to suggested safe levels or proposed standards for exposure to nonregulated pollutants cannot be made with a great degree of confidence. Oxy will either conduct or participate in programs to monitor steam quality and ambient air pollutant concentrations and to perform mass balance studies. The data base provided by these programs will aid in determining:

1. The need for further abatement of H_2S and other nonregulated pollutants in the future; and
2. The acceptability of additional power plant projects in the area.

In addition, there is a possibility that the construction and operation of the Oxy facility may degrade local recreation and drinking water supplies. Oxy has agreed to periodically monitor water quality in Anderson and Gunning Creeks to detect any chronic degradation so that appropriate corrective actions may be taken.

TRANSPORTATION

CEC staff does not expect the small increase in lightweight (auto/truck) traffic due to Oxy's construction to significantly impact the local transportation network. Oxy's increase in heavy truck traffic, however, will worsen existing problems on Socrates Mine Road. To mitigate, Oxy and other geothermal developers will share the costs of improving Socrates Mine Road.

If Oxy disposes of wastes in Middletown, their disposal trucks will add to an existing deterioration problem on Butts Canyon Road.

ENERGY AND MATERIAL RESOURCES

The Oxy #1 plant would consume approximately 1,500,000 lbs/hr of geothermal steam and will use a governor to throttle back unwanted steam. Oxy could maximize the use of geothermal steam by incorporating a more efficient turbine design.

On a cumulative level, Oxy #1's use of energy and material resources is about on a par with other geothermal developments in the KGRA, although they could improve on the efficiency of their steam utilization. CEC staff estimates that by 1986 a total of 24 geothermal power plants may operate in the KGRA and consume an estimated 28,305,000 lbs/hr of geothermal steam. Neither the capacity, duration, nor recharge rate of the geothermal steam reservoir is known, but staff recommends efficient use of this resource.

Aside from the geothermal steam, construction and operation of the Oxy plant will require some use of fossil fuel driven equipment. CEC staff considers these amounts of fuel as well as the amount of construction materials which Oxy will use to be insignificant.

CULTURAL RESOURCES

The Oxy development area contains one significant prehistoric hunting camp site, which is listed on the National Register of Historic Places. Oxy will establish a buffer zone to protect this site, although no construction activities are planned for the area. If Oxy implements all mitigation measures, no adverse impact to cultural resources should occur.

SOCIOECONOMICS AND PUBLIC SERVICES

CEC staff anticipates significant socioeconomic impacts due to Oxy and other geothermal developments. These will occur primarily in Lake and Sonoma counties and, to a much lesser extent, in Napa and Mendocino counties. Specifically, there will be an increased demand for housing on an already impacted housing market and an increased burden on public schools, especially within Lake County. Staff recognizes the potential for the Oxy development to cause a significant public service impact on the water system for Anderson Springs. Cautious engineering and adequate mitigation measures may dispell this concern.

AESTHETICS

Power Plant Site

The Oxy project will be visible from portions of the Colloyami and Longs Valleys to the east and from part of Highways 29 and 175. It will be partially visible from the vicinity of Anderson Springs, Middletown, and Whispering Pines, although geothermal development is common in the KGRA.

Transmission Lines

Oxy's preferred transmission corridor (westward over the ridge to SMUDGE #1) will be visible from the valleys to the east. However, the preferred route would be less visible than the alternate route which would traverse the ridge to the south-southwest.

Leasehold and Cumulative Impacts

Cumulative geothermal development (Oxy #1 and others) in this watershed will degrade the water quality of Anderson Creek. Anderson Creek mainly provides recreational waters for local residents, so the visual impact of increased sediment and pollution may lessen the creek's recreational appeal.

V. IRREVERSIBLE ENVIRONMENTAL CHANGES AND IRRETRIEVABLE COMMITMENTS OF ENERGY AND MATERIALS

Environmental categories not listed have no irreversible changes.

AIR QUALITY

During the 30-year lifetime of the plant, there will be a limited contribution to pollutant concentrations in the ambient air. Once the plant is decommissioned and the steam wells are no longer producing, the contributions to air pollution will cease. Thus, air quality will not be affected permanently and irrevocably, but it will be affected during the lifetime of the project.

HEALTH

CEC staff cannot determine from available data whether plant emissions will cause irreversible adverse health effects, but adherence to existing health standards on regulated pollutants should render impacts from regulated pollutants insignificant. Monitoring nonregulated pollutants and their effects will determine the need for additional abatement.

SOILS

During construction and for about three years afterward, an as yet unknown amount of soil will be lost because of power plant construction and subsequent erosion.

Oxy's full field development will remove vegetation and disturb soils on approximately 51 acres or 9 percent of the leasehold. Ordinarily, the amount of disturbance proposed by Oxy would not be alarming, but in this case the disturbance will occur close to creeks, on highly erodable soils, at the very top of a watershed which supplies both recreational and domestic waters to the town below. CEC staff concludes that the Oxy development will cause some loss of soil and vegetation. More importantly, soil erosion from the full development has the potential to degrade the quality of both recreational and domestic sources of water.

Oxy proposes to mitigate impacts due to erosion, but CEC staff feels that effectiveness of these measures is uncertain.

HYDROLOGY/WATER QUALITY

Based on average water consumption rates for other geothermal developments, staff estimates that Oxy will irrevocably commit approximately 4.5 million gallons (nearly 14 acre-feet) of water to the project. Of this, about 3.5 million gallons will be used during construction; Oxy will need the remaining 1 million gallons for initial charge to the cooling towers. Beyond construction and initial startup, Oxy will need less than one acre-foot of water per year to operate the power plant.

Oxy will purchase water for the plant and for steamfield development from outside sources. They will not use water from within the leasehold nor will they purchase water taken from either Anderson or Gunning creeks without the express permission of USGS and the local water master.

Oxy's leasehold is located at the top of the Anderson Creek watershed. Full field development will impact both Anderson and Gunning Creeks, although the degree of impact is uncertain. The presence of geothermal development at the top of the watershed will irreversibly commit the watershed to geothermal development, and will inevitably subject downstream users to potential impacts from such development.

Accidental Spills

If chemicals used in the H₂S abatement process were to spill and reach surface waters, they could cause adverse effects on the aquatic biota and recreational appeal of Anderson Creek. The health of those few families which use Anderson Creek as a source of domestic water could be adversely affected in case of a toxic spill. The entire power plant will be bermed adequately to hold the maximum possible spill, and Oxy will dispose of hazardous and toxic materials according to regulation. The proposed design, construction, and operation measures should serve to adequately mitigate against the possibility of adverse effects from accidental spills. Due to the location of the sumps and power plant, staff find it unlikely that any toxic materials would enter Gunning Creek as a result of the Oxy development.

BIOLOGY

Vegetation

Construction of the power plant and appurtenant facilities will remove approximately 21 acres of vegetation, and the full field development may take as much as 59 acres. Staff does not expect any species of particular environmental concern (rare, protected, endangered, etc.) to be lost, although Oxy has not yet completed an adequate rare plant study.

Oxy intends to operate the power plant for at least 30 years. If at the end of that time it is decommissioned, the facilities will be removed and the site revegetated.

Wildlife

The loss of vegetation from about 9 percent of the leasehold will result in similar reductions in wildlife habitat. These reductions will persist for the lifetime of the power plant. (Current projections by Oxy are for 30-years plant life.) When and if the power plant is decommissioned, the lease conditions require that with concurrence of the surface owner the leasehold be returned to its natural state.

The internal access road within the leasehold crosses Anderson Creek and leads out to well pad B which is located within 160° of Gunning Creek. The road and well pad encroach on the riparian protection zone proposed by BLM in 1978. Riparian habitat is particularly important to fish and wildlife in this area because it provides a source of water. CEC staff considers it likely that the fully protected ringtail occupies riparian habitat within the leasehold. Oxy will conduct studies to determine the presence of ringtail and whether

encroachment on the riparian habitat will have either a permanent or adverse impact.

ENERGY AND MATERIAL RESOURCES

Geothermal Resources

The Oxy geothermal plant will irreversibly consume 1,500,000 lbs/hr of geothermal steam. C staff estimates that by 1986 as many as 24 geothermal power plants may operate in the KGRA and will consume an estimated 28,305,000 lbs/hr of steam.

Reduction of the geothermal steam reservoir may occur; if so, the impact could be significant, particularly in view of the cumulative geothermal development in the KGRA. Because of the size, extent, and natural recharge rate of the steam reservoir are unknown, the potential rate of depletion is also unknown. To some extent, reinjection of geothermal fluids and steam condensate may mitigate this hazard, but the extent of possible mitigation is also unknown. Depletion of the geothermal resource would be a significant environmental change if the steam reservoir is not adequately recharged.

Other Energy Inputs and Material Resources

Implementation of this project would entail the commitment of the workers' time to construct it and a portion of the useful life of the equipment that could otherwise have been used to implement a different project. Considering the available supply, an insignificant amount of fossil fuel will be consumed for construction and operation of this project.

Much of the material used in the project such as concrete would be irreversibly committed, but some portions, such as various systems, components, and equipment, or structural steel, expensive metal alloys, and catalysts, may be reused. Fossil fuel used would be irretrievably committed.

LAND USE AND AESTHETICS

The commitment of the leasehold area to geothermal development will likely be an irreversible change. Other land uses will be permanently precluded in the area. The aesthetic impacts of the facility will also be permanent. However, if the project is eventually decommissioned, the area could be used for recreation and wildlife habitat, and if the facility is removed and the site revegetated, the aesthetic impact will be substantially reduced. Cumulative land use impacts in the KGRA may be irreversible, since areas once developed typically remain that way. Even if plant facilities are removed and sites are revegetated, roads would remain providing access to formerly undisturbed wildlife habitat.

VI. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE
ENVIRONMENT AND THE MAINTENANCE AND
ENHANCEMENT OF LONG-TERM PRODUCTIVITY

SHORT-TERM USES

The project provides short-term employment and other fiscal benefits to individuals in Sonoma and Lake counties. It will also cause stress on some of the public services and facilities such as schools and roads, especially during the construction phase of the project. It may also cause stress on the water supply system for the Anderson Springs community due to the potential to degrade the raw water; however, the extent of this possible impact is uncertain and should be viewed more appropriately within the context of cumulative impacts of current and further geothermal projects within the watershed.

With respect to water quality, trade-offs exist between the long-term (30-year) benefit of 80 MW of preferred geothermal energy versus the immediate impairment of beneficial uses and potential degradation of the waters in Anderson and Gunning creeks.

The Oxy #1 power plant, operating at 88 percent capacity, will generate 6.167×10^8 kWh/yr. The value of the output at 27.3 mills (2.73 cents) per kilowatt-hour would be \$16,835,910 per year.

The revenue to the federal, state, and county treasuries, based on a 12.5 percent royalty, would be :

Federal - \$2,104,489 minus 50 percent for the State =	\$1,052,244
State - \$698,798 minus 40 percent for the County =	631,347
County =	420,898
	<hr/>
	\$2,104,489

The economic advantage is apparent, since the estimated costs of protecting the Anderson Springs water system varied in capital costs from \$400,000 to \$1,000,000 with annual operational costs of \$40,000 to \$170,000.

If geothermal developers in the Anderson and Gunning creeks watersheds are unsuccessful in controlling erosion and sedimentation, however, the environmental and economic costs could escalate and last longer. Soil eroded from geothermal sites could contribute to surface water quality degradation and channel siltation all the way to Lake Berryessa and throughout the Anderson and Putah creeks system.

LONG-TERM PRODUCTIVITY AND CUMULATIVE IMPACTS

The proposed Oxy #1 project will offer long-term (30 or more years) benefits by providing electricity to the PGandE service area, while allowing PGandE to further diversify its electrical generation resource base. The proposed project will have potential long-term (greater than the life of the project) adverse effects on vegetation, wildlife, land use, aesthetics, and the geothermal resource (see Irreversible Environmental Changes Section). Because use of geothermal resources for electrical generation is relatively new, the significance of some of its effects is unknown, including the potential health effects of long-term exposure to varying concentrations of hydrogen sulfide and other potentially deleterious components of geothermal steam and emissions and the long-term production capacity of the KGRA.

If the steam for the project proves to be a reliable long-term source for electrical power, the benefits of development will be long term, but the adverse impacts could also increase proportionally.

VII. GROWTH-INDUCING IMPACTS

Geothermal development in the KGRA has induced some growth in Napa, Mendocino, Lake, and Sonoma counties. Roads in the latter two counties are affected, while the public schools in Lake County have been particularly impacted by the influx of geothermal workers' families. Impacts of this type are cumulative in nature, so, while the Oxy #1 proposal would contribute growth impacts to both counties, it would not be the sole source. All geothermal developments contribute to growth within the counties; although the impacts are somewhat dispersed, so far Lake County has demonstrated the greatest geothermal related impact on their schools.

To mitigate the more drastic impacts to Lake County, Oxy offers to provide construction workers with a van pool for transportation to work in Lake County. Designed to provide workers with incentives to locate in Sonoma County, the proposed transportation program will shift craft union workers to the Sonoma County site of the KGRA. Additionally, the school districts in Lake County can apply for monies made available through AB 1905 to further mitigate impacts to the schools. Regarding impacts to County roads, Oxy entered into an agreement with Lake County to pay for their proportionate share of cost to upgrade Socrates Mine Road.

VIII. ALTERNATIVES TO THE PROPOSED PROJECT

There are a wide variety of potential alternatives to the proposed project power plant. These alternatives assume that the basic need and purpose of the project is to supply 80 MW net of baseload generation capacity by May 1984. The alternatives are no project, alternative location, alternative facilities, alternative size, alternative designs, alternative means of accomplishing project objectives, alternative transmission facilities, alternative steam gathering facilities, and alternative uses of geothermal steam.

NO PROJECT

The Oxy #1 power plant would generate 615 million kilowatt-hours (kWh) of energy each year (based upon an 88 percent capacity factor). Denial of this project will impede state efforts to diversify power sources and expedite geothermal development in order to increase reliability and reduce dependency on fossil and nuclear based electrical generation.

ALTERNATIVE LOCATIONS

The location of a geothermal power plant is limited to areas containing proven geothermal resources within a designated leasehold and to specific areas within that leasehold in regard to topographic and geologic features and environmental concerns. In addition, Oxy should locate the power plant at a distance no greater than one mile from each geothermal steam supply well. Transport beyond this distance causes the steam to lose the temperature and pressure required to efficiently operate the steam turbine.

Oxy selected their proposed and alternative sites based on the site selection criteria* listed below:

SITE SELECTION CRITERIA

Category I (Mandatory)

- o On the leasehold.
- o Slope less than 2:1.
- o Adequate space available.
- o No geologic hazard (fault, landslide).

Category II (Avoid or Mitigate)

- o Rare and endangered species.
- o Critical habitats.
- o Sensitive paleontological, archaeological, or ethnic areas.
- o Adverse atmospheric dispersion characteristics.

*Oxy #1 AFC, Table 1.1-1.

Category III (Evaluate)

- o Mineral resources.
- o Earth work required for site preparation.
- o Site development costs.
- o Central location to minimize steam lines.

The major factors determining potentially suitable sites are the topography (slope) and geologic hazards such as landslides and faults. These combined with the other criteria resulted in only two potential site areas, labeled "preferred" and "alternate Site 1" on Alternative Site Selection, Figure 1.

Both the preferred and the alternative sites are near the ridgetop, which may correspond with favorable atmospheric dispersion characteristics. As discussed in the appropriate Biology and Cultural Resource Section of the AFC, the other criteria of Category II are satisfied. As discussed in AFC Section 1.1.2 (Site Selection), the choice between the two potential sites was resolved on the basis of the least amount of earthwork necessary and the best overall site stability as determined by geological investigations.

Based on these considerations, Oxy determined that the most stable site would be "preferred". CEC staff concurs in this determination.

ALTERNATIVE FACILITIES

The primary determinate for consideration of alternative facilities is the time required for planning, design, licensing, and construction of an alternative facility in relation to the date when the electricity is scheduled to be on line. Due to the long lead times required to construct coal-fired, nuclear, and hydroelectric generating plants, these types of plants are not considered as feasible alternatives to the project.

New energy sources such as fuel cells, solar, tidal energy, magnetohydrodynamics, and wind power have limited applications, may not be commercially available within the necessary time frame, and would not provide sufficient base load reliability comparable to this project. Oil-fired generating plants such as combined-cycle units, the repowering of existing generating plants, and cogeneration are all possible alternatives because the lead time required from planning to operation varies from slightly less to a little more than the time required for a geothermal project. However, using fuel oil for combustion purposes is contrary to the federal Powerplant and Industrial Use Act, which precludes the use of fuel oil for new generation facilities with only a few exceptions.

ALTERNATIVE SIZE

Oxy proposes to build a power plant which will generate a net of 80 MW. Geothermal power plants of a smaller magnitude are feasible, but they do not significantly reduce the initial environmental loss due to power plant construction. Therefore, an optimal design is desirable. Geothermal power plants can be large or smaller in size. In The Geysers KGRA, the PGandE

Source: Oxy #1 AFC

FIGURE 1: LEASEHOLD-Alternative Site Selection

Geysers Unit 13 power plant currently produces 135 MW, the largest in The Geysers. PGandE's Geysers Unit 17 and 18 (recently certified by the Commission) and its proposed Geysers Unit 16 are all rated at 110 MW. Some geothermal plants, such as PGandE Unit 15 and the DWR Bottle Rock project, are each 55 MW. The smallest power plant in The Geysers is PGandE Unit 1, which produced only 11 MW.

The components of a geothermal generating facility which allow some flexibility of design are the cooling systems, hydrogen sulfide abatement systems, and turbine design.

Oxy's current design will use 1,500,000 lbs steam/hr. to generate a net of 80 MW. If Oxy would adopt an improved turbine design, CEC staff believes that Oxy could:

- A. Use 1,200,000 lbs steam/hr to generate 80 MW net, and that more efficient use of steam would allow Oxy to,
- B. Extend the life of the power plant by approximately six years, or
- C. Using the current 1,500,000 lbs steam/hr, with improved turbine efficiency, Oxy could generate a net of 100 MW. Although such a design would result in higher net generation, it would not extend the life of the plant beyond Oxy's current projection of 30 years.

Proposed Cooling System

The proposed cooling system is comprised of a surface condenser, which condenses the steam exhausted from the turbines, and two five-cell, fan-assisted, wet-type cooling towers, which cool the water heated during its passage through the surface condenser.

Prior to start-up of the power plant, the cooling system will be charged with approximately 1,000,000 gallons of water. Oxy will purchase this water from outside the leasehold. Once the power plant is in operation, the initial start-up water lost during the evaporative cooling process at the cooling tower will be supplemented by steam condensate from the surface condensers. Excess condensate not needed to replace cooling water lost through evaporation and draft emissions will be reinjected into the steam reservoir.

Alternative Cooling Methods

- o Direct Contact Condenser--This system has been used by PGandE in their Geysers Power Plant Units 1 through 12. In this cooling method, steam exhausted from the turbines is mixed directly with the cooling water and then pumped to the cooling tower. The initial cost of this system is less than a surface condenser, but it does not give the degree of H₂S partitioning that can be achieved with the surface condenser in conjunction with the Stretford process for H₂S abatement.
- o Air-Cooled Condenser--With this system, the exhaust steam from the turbines is condensed in a tubular type of heat exchanger by air passing

over the tubes. This system has three major disadvantages: large size, greatly increased cost, and decreased operating efficiency. An air-cooled condenser requires an extremely large surface area in order to be effective, and the chemical and physical properties of the steam in The Geysers require use of higher cost materials, thereby increasing costs. The efficiency of the power plant and Stretford H₂S abatement unit would probably be reduced because of size factors associated with an air-cooled condenser, which would increase turbine back-pressure much of the time.

- o Closed Cycling Cooling--The cooling water, in a closed-cycle system, circulates within a closed system using surface condensers and indirect contact, water-to-air, "dry" cooling towers. All the condensate would be reinjected if such a system were used for the proposed plant site. The noncondensable gases in the steam would still have to be removed from the condenser and treated to comply with air quality standards. However, complete reinjection would eliminate H₂S emissions that occur in direct water-to-air contact type towers.

The use of a closed-cycle cooling system would approximately double the total cost of the proposed power plant. The capital cost of a closed-cycle system could be reduced by reducing the capacity of the plant during the summer peaking period, but this would reduce the value of the generating capacity.

- o No Cooling System--In this system, the turbine exhaust steam is discharged directly to the atmosphere from the turbine and requires no cooling. This system was considered in early geothermal power cycle studies but was found to be very inefficient due to the level of back pressure in the turbine units. In order to generate the same amount of power much more steam is required per unit of power generated. Direct discharge of the exhaust steam to the atmosphere also requires consideration of noise mitigation and would not comply with air quality standards.
- o Once Through Cooling System--Use of this system would eliminate the need for a cooling tower but is not considered for the Oxy #1 project since the large water supply required is not available in The Geysers areas nor within economically reasonable transport distance.
- o Natural-Draft Cooling Tower--A natural-draft cooling tower is not practical for a power plant of this size, since it would have to be very large to create the required air flow. In addition to creating greater visual impact, the large natural-draft towers would also compound the difficulty of locating satisfactory plant sites in the mountainous terrain of The Geysers KGRA. The cost of this type of tower is several times greater than the cost of the proposed mechanical-draft cooling tower.

Proposed H₂S Abatement Systems

Oxy will use the combination of improved surface condenser turbine by-pass devices to deal with occasional steam venting conditions* and Stretford chemical scrubbing process to initially reduce the H₂S emissions. Further reduction of H₂S emissions, if required by the APCO in the Determination of Compliance, will be accomplished with a secondary abatement system using hydrogen peroxide with catalyst.

o The Stretford Process

The Stretford and H₂O₂ abatement systems scrub the steam once it is exhausted by the turbine. After leaving the turbine the steam condenses and splits into two flow paths. One path contains gaseous chemical constituents including H₂S, while the other flow path contains liquids. The gas flow path contains the majority of the H₂S. This gas stream passes through the primary abatement system which employs the Stretford chemical scrubbing process to treat the H₂S.

o H₂O₂ with Catalyst

The second flow path contains liquids resulting from the condensed steam and includes chemical constituents such as H₂S which are absorbed by the liquid. This second path containing the smaller amount of H₂S, also requires treatment in order for the plant to meet H₂S emission standards. SMUD's secondary abatement system will employ hydrogen peroxide with a catalyst to promote a high H₂S removal efficiency.

o Turbine By-Pass

As part of the overall H₂S abatement system, a piping system will be installed to divert steam around the turbines to the surface condensers during plant start-up or shut-down conditions. This will give the steam access to the abatement systems; without this system, steam would vent into the air untreated.

Alternative H₂S Abatement Systems

- o The Metal Catalyst System—Hydrogen sulfide dissolved in water, in the presence of air and at normal temperatures, is unstable and undergoes oxidation to form free sulfur. This reaction is ordinarily slow but can be accelerated by use of appropriate catalysts such as dissolved ferric ion. In the process the ferric ion is regenerated so that more hydrogen sulfide is oxidized. The iron concentration in the cooling water is maintained at 30 ppm by weight or higher. The condenser off-gas is released in the cooling water so that its hydrogen sulfide content is

*Steam venting occurs during plant start-up or shut-down. This condition, known as "stacking," would send untreated steam into the air unless corrective measures are taken.

also oxidized. The major problems associated with the iron catalyst system are corrosion of metal parts in contact with the cooling water and rapid accumulation of sludge.

A metal catalyst, supplemented either with hydrogen peroxide or with caustic soda, is being used at PGandE Units 3 and 6 and Unit 11. This system will also be used at other PGandE Units only during H₂S episodic alert days.

PGandE reports that they have achieved 90 percent abatement in their existing direct condenser units by use of high concentrations of iron catalyst. However, systems using this form of abatement experienced serious operational problems which caused reduced reliability due to sludge formation and induced corrosion. By using an iron catalyst with their H₂O₂ system, SMUD can probably avoid such reliability problems. This is due to the small quantities of H₂S as well as the nature of the catalyst itself.

- o Sulfur Dioxide pH Control--Injection of sulfur dioxide (SO₂) into the condensate to control the pH of the condensate and to displace the H₂S dissolved in the condensate is an attractive method for reducing the amount of H₂S in the condensate. Sulfur obtained from the Stretford process could be burned to provide a readily available source of SO₂.

Significant development and prototype testing remain to be done on this system before it can be adapted for commercial use. However, if the Stretford process does not provide the necessary H₂S abatement, the use of sulfur dioxide pH control should be considered and evaluated as a secondary H₂S abatement method.

Other H₂S abatement systems which have been or could be used are discussed below. Most have proven ineffective or have been displaced by the Stretford and surface condenser/partitioning process.

- o EIC Process

This process is one that can treat steam upstream of the power plant. It removes the H₂S in the steam by a scrubbing process similar to the Stretford process. It uses a chemical solution whose main constituent is copper sulfate. The system has not been used commercially; however, it has undergone pilot plant testing on one well at a PGandE plant in The Geysers under a development contract funded by the DOE. The attractive features of the process appear to be:

- (a) Potential for high H₂S abatement efficiency and partial removal of other desirable steam constituents.
- (b) Potentially superior combined capital/operational cost aspects than the Stretford and hydrogen peroxide system combination costs.
- (c) Regeneration capability of the chemical solution in the scrubbing process.

- (d) Potentially cleaner steam supply to the power plant, which in turn reduces potential problems or maintenance at the plant.
- (e) H_2S abatement capability in a steam stacking process.
- (f) Waste that is generated in the EIC process is joined with the cooling tower purge stream to be reinjected.
- (g) Potential for retrofitting existing power plants.

The unknown aspects are:

- (a) Actual abatement efficiency as a commercial process.
- (b) Reliability of the system.
- (c) Carry-over of chemical products to the power plant that may be detrimental to the plant.
- (d) Total costs.

Although the EIC process has not been used commercially, the Department of Water Resources proposes to use it on their Bottle Rock project in Lake County. The H_2S concentration for the Bottle Rock project is so high that the EIC process will be installed in addition to two other abatement techniques. Oxy #1 does not have such high H_2S concentrations; so Oxy can reduce its emissions adequately using only Stretford and H_2O_2 with catalyst.

- o Steam Converters--An old geothermal industry process, the steam converter, was the only effective way of reducing the high gas content of the steam. However, the process seriously degrades the quality of the steam, and nearly double the mass of steam is required to produce the same amount of power as unconverted steam.
- o Preplant Oxidation--PGandE has briefly experimented with the injection of oxygen (O_2) into the incoming geothermal steam, upstream of the turbine units. The results were not encouraging, since injection of twice the amount of O_2 theoretically required for full oxidation only caused an H_2S reduction of 5 percent. Upstream injection of H_2O_2 has also been tried but with poor results.
- o The Burner-Scrubber System--This system mixes the condenser off-gases with air and burns them. The system was used on PGandE's Unit 4 but was discontinued because it was unable to reduce H_2S emissions by more than one-half of that required and because the off-gases are only marginally flammable.
- o The Deuterium Process--The Deuterium Corporation has installed and tested a liquid absorption type of scrubber to remove H_2S from a portion of the incoming steam at PGandE's Unit 7. Details of the process are considered proprietary information, but early test results indicated 90 percent or better H_2S abatement. There were problems associated with regeneration of scrubber solutions which have yet to be resolved.

ALTERNATIVE TRANSMISSION FACILITIES

TRANSMISSION ROUTES

Oxy will construct a double circuit transmission line from the proposed power plant to an existing 230 kV transmission line in The Geysers. Oxy proposes to string one circuit initially. Oxy identified two alternative termination points in The Geysers at which to terminate their tapline--a preferred and an alternative (see Transmission Figure 1).

THE PREFERRED ROUTE

The preferred tapline route would terminate on the recently certified SMUDGE #1 double circuit tapline, which is scheduled for completion in 1983. The preferred route would require three (3) transmission towers and would be constructed within 4,700 feet of new right-of-way between the Oxy site and the SMUD Tower C-2. When SMUD builds their tapline they will string only one of the two circuits. When Occidental constructs their tapline, the second circuit of the SMUDGE #1 tapline will be strung for Towers C-2 and C-3 to the PGandE line.

The tap itself would be 4,700 feet long and would use 1,800 feet of the SMUD tapline.

Oxy will locate each of the proposed tower locations near an existing access road, so that no new access roads would have to be constructed.

THE ALTERNATIVE ROUTE

Oxy also identified an alternative tapline which would be 5,400 feet long and would terminate on the existing Unit 13 tapline, approximately 3,000 feet from the collector line. This alternative route would require four (4) transmission towers and approximately 2,300 feet of new access road.

Comparison of Preferred and Alternative Routes

The preferred route (1) requires less transmission construction and new right-of-way (4,700 feet as compared to 5,400 feet), (2) requires no new access roads (compared to 2,500 feet for the alternative route), (3) is preferable aesthetically, (4) has comparable transmission losses and overall costs compared to the alternative route, and (5) would require less disturbance of vegetation than the alternative and would therefore result in reduced potential for soil erosion and impact to wildlife species.

Comparison of Conductor Sizes

Oxy originally proposed to use 795 kcmil ASCR conductors. They have subsequently evaluated the following conductor sizes:

- (1) 795 kcmil bundled*
- (2) 1113 kcmil
- (3) 1113 kcmil bundled
- (4) 1431 kcmil
- (5) 1431 kcmil bundled

*Two conductors per phase.

OXY GEOTHERMAL #1

Source: Oxy #1 AFC

LEGEND

- OXY SITE
- × PROPOSED OXY TOWER SITES
- ▲ PG&E UNITS
- △ EXISTING PG&E TOWERS
- SMUDGE #1
- PROPOSED SMUD TOWERS
- EXISTING ROADS AND TRAILS
- - - PROPOSED TRANSMISSION ACCESS ROADS

FIGURE 1: TRANSMISSION-Proposed and Alternate Transmission Routes

These calculations indicate that 795 kcmil, 795 kcmil bundled, and 1113 kcmil have comparable costs, when considering transmission losses. Accordingly, Oxy is considering using the 795 kcmil bundled circuit, since it would reduce transmission losses by approximately 50 percent (54 MWh/year) at no increase in costs.

Transmission Structures

The Applicant proposes to use steel lattice towers (see Transmission Figure 2). Although the Applicant could propose steel pole type towers, only steel lattice type towers have been used to date in The Geysers. In addition, some observers consider the lattice type towers to blend into the natural environment better than the pole-type structures which may be more visible against the brush and tree covered hillside. Also, the lattice type structures are generally superior in regard to structural stability in the unstable terrain typical of The Geysers. In building their transmission structures, Oxy will comply with the following provisions (81-AFC-1, p. 8 - 6):

FAA-49 USCA 1348
14 CFR, Part 77

FCC-47 USCA 151 et seq.
47 CFR, Part 15.25; and

California Division of Aeronautics--PUC 21655 et seq.
21 CAL 3500 et seq.

An underground, low pressure, oil filled, self-contained cable could be used as an alternative for the overhead transmission line. This underground cable has generally not been used in The Geysers area. It is quite expensive--approximately five to ten times as expensive as overhead transmission. Underground transmission would require excessive cleaning, grading, and trenching. Undergrounding the proposed transmission line would reduce the visual impact and physical obstruction, but the greatly increased cost and potential effects of erosion or slope failures on cable reliability make this an undesirable alternative.

DOUBLE CIRCUIT 230 kV TOWER

Source: Oxy #1 AFC

FIGURE 2: TRANSMISSION-Transmission Structures

ALTERNATIVE MEANS OF ACCOMPLISHING PROJECT OBJECTIVES

Energy Conservation

The discussion of need in the chapter on "Project Description" refers to the Energy Commission's adopted forecast for energy and peak demand. The forecast incorporates some conservation measures. New and expanded measures are being implemented by PGandE in an effort to reduce electrical demand in the PGandE service area, which Oxy's 80 MW generation will help serve.

Geothermal base load electrical generation is specified by the Energy Commission as a "preferred" technology (CEC, 1978) and is relatively cost effective compared to other alternative electrical generation technology. Conservation is an alternative technology that would be more applicable as an alternative to other less preferred and less cost-effective forms of electrical generation.

ALTERNATIVE STEAM GATHERING FACILITIES

Alternative Structures

In order to maintain the high temperature of the geothermal steam, it must be transported in insulated pipes. Physical and chemical properties of the steam resources constrain the types of materials feasible for use in construction of the gathering steam. Since the steam often carries solid debris and other foreign materials which settle out as the steam is transported, the steam gathering system must have vents and centrifugal filters at intervals along the pipeline. These vents and traps must be accessible for periodic cleaning and maintenance. For these reasons an above-ground construction of the steam gathering system is preferred.

Alternative Location or No Development Alternative for Well Pad B

In view of the potential water quality problems presented in the Cumulative Environmental Analysis Section, an alternative would be to not develop this leasehold because of its location at the head waters of both Anderson and Gunning creeks or reduce the amount of steam which could be developed by eliminating Drill Pad B. Assuming that the purpose of Oxy's steamfield development is to supply the Oxy #1 power plant with steam, it may be possible to eliminate the need for Well Pad B if Oxy would (a) adopt a plant design which improved steam use efficiency and (b) reduce their target capacity if the elimination of Well Pad B leaves insufficient steam to power the proposed 80 MW facility. However, with respect to the latter contingency, Oxy currently holds federal permits to develop the steam within their leasehold regardless of the presence of a power plant on the leasehold. The problems in developing Site B were voiced by the environmental staffs of the USGS, BLM, and California Department of Fish and Game during the initial evaluation of Site B. (USGS Environmental Assessment 131-80.)

Alternative Routes

In order to maintain the maximum usefulness of the natural steam resource, the distance between the steam supply and the power generating facilities must be minimized. The exact location of the steam supply pipelines and support towers associated with the Oxy #1 project are listed in the federal environmental documentation identified in the SUMMARY portion of this document, under "Steamfield." The policy of the federal agencies which manage steam development within the proposed project leasehold is to encourage the lessee of the lands to route the steam gathering system along the existing system of access roads constructed during the development of the geothermal resource. Oxy also prefers to route the gathering system along already existing roads, since it provides easier access for maintenance of the system and reduces costs. As the steam developer, Oxy has constructed an access road within the leasehold which fulfills this purpose.

ALTERNATIVE USES OF GEOTHERMAL STEAM

In addition to its use for electrical generation, geothermal steam can be used for a variety of domestic and industrial processes. Typically, these processes depend on a resource with a 100° to 150° temperature range, which is considered "moderate." Direct heating uses of geothermal energy include water heating, space heating and cooling, food processing, refrigeration, and process-heating applications. The most common of these uses are direct heating for buildings or for industrial dehydration processes. The most efficient uses of this heat require that the user be not more than a mile away from the resource due to heat loss in transportation, and there are not residences within this distance. Geothermal resources above 150°C are considered to be potential for commercial power production; these additional temperature resources could also provide process heat to favorably located industries. The steam resources at The Geysers are about 250°C.

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GLOSSARY

AEROSOL	A colloid system of solid or liquid particles dispersed in a gas.
ALPHA ENERGY	Energy from the positively charged alpha particle emitted by certain radioactive materials. It is unable to penetrate the epidermis of skin but when inhaled or ingested is considered dangerous.
AMBIENT	Natural, existing.
AMBIENT TEMPERATURE	Natural temperature of the environment at a given time.
ANNUNCIATOR SYSTEM	A device which monitors and actively or passively informs a plant operator of the status and functioning of various systems within a power plant, e.g., a horn or flashing light indicating overflow of the cooling tower basin.
AQUIFER	Any geological formation containing water, especially one that supplies water for wells, springs, etc.
ARCHAEOLOGY	That branch of anthropology concerned with the identification, description, and classification of sites, artifacts, or other evidence of prehistoric peoples or cultures. With respect to the Western Hemisphere, this includes the Native American era.
BACT	Best available control technology; often used in reference to mitigation measures for maintaining air and water quality.
"BARELY AUDIBLE"	A term that refers to a noise level that would require a conscious effort to be heard.
BEDLOAD	The sediment that moves by sliding, rolling, or bouncing on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at a velocity less than that of the surrounding flow.
BERM	A ledge or shelf, typically one that contains or guides drainage at the top or bottom of a slope. Also, an artificial ridge of earth.
BLEED	Small amount of steam vented to atmosphere when well is shut in.
BLOOIE LINE	A pipe used to carry fluids and cuttings from the well to a muffler/separator during air drilling operation.
BLOWOUT	An uncontrolled eruption of a geothermal steam well.

BORROW PIT	An excavation made to obtain earth, rock, etc., for use as a construction material. The low lying areas on either side of a roadway from which material has been drawn to build up the crown of the road and to receive run-off and carry it away from the travelled surface of the roadway. In some areas of the western United States colloquially referred to as "barrow pit" probably because of the use of wheel barrows and hand labor to build early dry roadways.
CAPACITY	The ability of a power plant or generating unit to produce a certain level of power, usually expressed in kilowatts or megawatts.
CARCINOGENIC	Those agents which can cause cancer.
CATCH BASIN	See DEBRIS BASIN.
CATCH DAM	A small, usually earthen, dam placed across a streambed to slow down the water and cause the transported sediment to settle out. See also DEBRIS BASIN.
CHRONIC	Of long duration; continuing.
Ci/ML (CURIES PER MILLILITER)	A measure of concentration of radioactivity in a substance.
CIRCULATING WATER	The water used to cool the steam in the condenser; consists of recycled and new condensate.
CLASS I DISPOSAL SITE	A site which lies over a usable groundwater source but which has a natural geologic barrier which prevents the vertical or lateral transfer of leachate from the disposal site to the groundwater.
CLASS II-1 DISPOSAL SITE	A site which lies over a usable groundwater source but which has been modified to prevent the vertical or lateral transfer of leachate from the site to the groundwater.
CNEL	Community Noise Equivalent Level--A weighted measure of the cumulative noise exposure produced by a series of distinct noise events during three periods of the day. A 10 decibel penalty is applied to the nighttime levels and a 5 decibel penalty is applied to the evening levels.
CONDENSATE	The liquid which results from the condensation of geothermal steam.
CONSTITUENTS	As used in referring to water quality, the chemical components of a waste in a body of water.
COOLING TOWER	Structure in which heat is removed from hot condensate taken from the condenser.

CUBIC FEET PER SECOND	A unit expressing rates of discharge. One cubic foot per second is equal to the discharge of a stream of rectangular cross section one foot wide and one foot deep, flowing at a velocity of one foot per second. Also written c.f.s., ft ³ /sec, and cu. sec.
CULTURAL RESOURCES	As used in this document, this term encompasses four major categories of resources important to man's knowledge of himself and his appreciation of life on earth. These categories include: paleontological resources, archaeological resources historic resources, and other resources of educational, scientific, religious, or cultural significance which have been identified through ethnographic research.
CUT AND FILL	Construction term referring to earth removal at a site (cut) and disposition of the excess dirt (fill).
DEBRIS BASIN	An impoundment to trap floating or submerged trash, suspended sediment, and bed load.
DECIBEL (dB)	One tenth of a Bel - a measure of sound pressure.
DECIBELS A-WEIGHTED (dBA)	Sound pressure levels weighted in accordance with "A" scale. A-weighted scale expresses the relative insensity of sounds, similar to the response of the human ear. Two represents the faintest audible sound; 130-140 Represents the average pain level.
DECIDUOUS	Vegetation that loses its leaves annually, generally in fall or winter.
DEW POINT	The temperature to which a given parcel of air must be cooled at constant pressure and constant water vapor content in order for saturation to occur.
DIELECTRIC	Nonconducting.
DOC	Determination of Compliance; document issued by County Air Pollution Control District which asserts compliance with county air pollution regulations.
DOWNWASH	Meteorological condition in which high velocity (greater than eight meter/sec) air movement across a ridge top is deflected downward into an adjacent valley or less side of the ridge by mechanical fluid motion.
DRAWDOWN	Lowering of the water surface (in open channel flow), water table, or piezometric surface (in ground water flow) resulting from a withdrawal of water, e.g., by pumping a well.
DRIFT	The gaseous and aqueous plume which comes out of the cooling tower and is dispersed by meterological conditions or deposited on the surrounding environment.

DRIFT ELIMINATOR	A mechanical device composed of an array of metal fins which captures airborne droplets of water rising in a cooling tower and causes them to drop back into the water reservoir.
DRY STEAM	Hot steam which contains no condensate.
EDGE	The division between two adjoining habitats.
EFFLUENT	Water or waste stream which flows out of a treatment facility.
ENTRAINMENT	The mixing of environmental air into a pre-existing organized air current so that the environment air becomes part of the current.
EMISSION	Material passed into the atmosphere in a gas stream; may contain an air contaminant.
ENERGY DISSIPATOR	Structures or materials placed at the outlet end of a culvert or drain pipe to remove the energy of the the water and reduce its ability to erode the soil. Often a pile of large rocks serves as an energy dissipator.
ETHNOGRAPHIC	Related to the branch of anthropology concerned with the classification and description of regionally different human cultures.
FAULT	A fracture or fracture zone in the earth's crust along which parallel slippage of adjacent earth material has occurred.
FAUNA	Animals of a specified region.
FEN	An area of low, flat, marshy land.
FLASK	A unit of measure equalling 76.5 pounds.
FLORA	Plants of a specified region.
FRANCISCAN ASSEMBLAGE OR FORMATION	A geologic rock formation comprised primarily of graywacke conglomerate and shale with overlying volcanic deposits. This formation is thought to represent a deep ocean trench deposit which has gradually converged with and been carried under the Great Valley Sequence.
FREQUENCY	The average interval of time between natural events equal to or greater than a specified size. It is generally expressed in years, i.e., one-in-a-hundred-years (1:100) flood. For a 1:1000 event the odds are 1000 to 1 against such an event being equalled or exceeded in any particular year.
FUMAROLE	A naturally occurring hole in geothermal areas from which hot steam and gases arise.

FUMIGATION	When mixing depth is at the same height as the plume center line causing rapid mixing of pollutants to the ground.
GAUSSIAN	A "Bell-Shaped" distribution of pollutant concentrations, similar to a "normal" distribution in statistics.
GEOHERMAL STEAM	Steam created by the heat of the earth.
GEYSER	Spring that throws forth continuous or intermittent jets of heated water and steam.
GRAYWACKE	In geology, a type of sandstone rock which is comprised of varying percentages of quartz, feldspar, and fragments of other types of rock such as slate or schist. This is the predominant type of rock in the Franciscan Assemblage.
GREAT VALLEY SEQUENCE	A geologic rock formation consisting mainly of sandstone and shale, mudstones and siltstones, and conglomerate lenses and beds. This sedimentary formation is thought to represent rocks originally deposited along the continental margin, considerably to the east of the Franciscan depositional site. During a long period of tectonic movement, this formation gradually converged with and overrode the Franciscan Assemblage.
GRID CELL	A three-dimensional division of air space (50' vertically by 500' on each side) for the purpose of air quality modeling studies.
GROUNDWATER	Water found underground in porous rock strata and soils.
H ₂ S	Hydrogen sulfide; a natural emission from geothermal fumaroles which gives off a strong odor; a sort of air pollution which is common to geothermal developments.
HABITAT	The environment where a plant or animal lives.
HAZARDOUS WASTE	A hazardous waste is one which, because of its quantity, concentration, or particular characteristics, may cause severe illness or pose a threat to human health, safety, or the environment when improperly stored, disposed of, or otherwise managed (California Health and Safety Code, Division 20, Chapter 6.5).
HISTORIC RESOURCES	Sites, structures, artifacts, routes, and other evidence of peoples and cultures dating forward from the time of written history, which in the Western Hemisphere, is considered to coincide with European arrival in individual locales.
HYDROTHERMAL	Of or pertaining to heated water.

IGNEOUS	Rock material formed by cooling and solidification of molten magma, either at the surface, such as volcanic rock, or at depth.
INSOLATION	Solar irradiation.
INVERSION	An atmospheric condition where a layer of cool air is trapped by a layer of warm air so that it cannot rise. Inversions spread polluted air horizontally rather than vertically so that contaminating substances cannot be widely dispersed.
"K" FACTOR	The soil erodability factor "K" used in the universal soil loss equation is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It is a value, less than unity, determined experimentally for selected benchmark soils.
KILOWATT (kW)	1,000 watts.
KILOWATT-HOUR (kWh)	The basic unit of electric energy equal to one kilowatt (1,000 watts) or power supplied to or taken from an electric circuit steadily for one hour.
LCAPCD	Lake County Air Pollution Control District.
L _{dn}	Day-night average sound level--the 24 hour A-weighted equivalent sound level, with a 10 decibel penalty applied to nighttime levels.
L _{eq}	Energy equivalent level or equivalent sound level is the <u>steady</u> noise level which in a stated period of time would contain the same noise energy as the time-varying noise during the same time period.
L _{max}	Maximum A-weighted sound level for a given time or event.
L _{min}	Minimum A-weighted sound level for a given time or event.
L _x	The statistical level of noise which is exceeded x percent of time during the observation interval, dB. Three common statistical parameters are L ₁₀ (high level), L ₅₀ (median level), and L ₉₀ (low level).
LEACHATE	Drainage from a waste or fluid resulting from the percolation of liquid through a waste substance.
LEASEHOLD	An area leased by a steam supplier for geothermal development.
LIMITED MIXING	Atmospheric condition where a layer of neutral stability extends above ridgeline and is capped by a stable layer.
MAGMA	Molten rock material within the earth from which an igneous rock is formed by cooling.

MAXIMUM CREDIBLE	A design value which represents the expected maximum event (e.g., earthquake, rainfall) which a structure will have to withstand.
MAXIMUM PROBABLE	A value for a natural event (e.g., earthquake, rainfall) which is derived from statistical analysis of historic occurrences magnitudes and the probability that they will be equalled or exceeded within the lifetime of the structure being designed.
MEGAWATT (MW)	1,000 kilowatts or 1 million watts.
MEGs	Multimedia Environmental Goals (EPA, 1977) lists "levels of significant contaminants...in ambient air...that are judged to be appropriate for preventing certain negative effects in surrounding populations." See Appendix C for details.
MELANGE	Mixture of incongruous elements of soil and rock; in the Franciscan Formation this refers to the presence of variable blocks of stable rock in a matrix of sheared and pulverized rock.
MESIC	A habitat characterized by a moderate amount of water.
METAMORPHIS ROCK	Rock changes by combinations of pressure, heat, and water solutions.
MICROGRAMS PER CUBIC METER (ug/m ³)	A measure of concentration of a pollutant in air. A microgram is one millionth (10 ⁻⁶) of a gram.
MILLIGRAMS PER CUBIC METER (mg/m ³)	A measure of concentration of a pollutant in air. A milligram is one thousandth (10 ⁻³) of a gram.
MICROCLIMATE	The conditions of temperature, humidity, wind, etc., immediately surrounding an organism or in a particular habitat.
MODELING STUDIES	With respect to air quality, computer simulation of air pollutant transport and dispersion.
MORPHOLOGY	The form and structure of plants and animals.
MUFFLER	Device for sound attenuation through which steam is directed during periods of release, such as stacking, to the atmosphere.
NATIVE SPECIES	Flora or fauna which would normally or naturally occur in an area unaffected by human entry or use.
NATURAL BACKGROUND RADIATION	That radiation which is not man-made and originates from terrestrial (pertaining to the earth's crust) and cosmic (pertaining to outer space) sources.

NATURAL RECHARGE AREA	An area of very permeable soil through which rainwater percolates to replenish groundwater aquifers.
NOCTURNAL DRAINAGE	Meteorological condition in which low velocity (less than 3 m/sec) air flows occur near the ground surface on hill-sides and in valleys, trapping pollutants, and confining them near the ground.
NONCONDENSIBLE GAS	Gases contained in geothermal steam which are not condensed or absorbed into liquid condensate.
NSCAPCD	Northern Sonoma County Air Pollution Control District.
ONE-IN-A-HUNDRED	When applied to surface run-off and rainfall it means that the odds are 99 to 1 against such an event being equalled or exceeded in any particular year.
PALEONTOLOGY	The branch of anthropology concerned with the study of fossilized evidence of prehistoric plants and animals.
PARTICULATES	Any material, except uncombined water, which exists in a finely divided form as a liquid or solid at standard conditions.
PATH TREATMENT	A reduction of noise at the receiver's position due to a physical change in the path of sound between source and receiver.
PATHOGEN	A microorganism or substance capable of producing a disease.
PERCHED WATER TABLE	Groundwater supported by a layer of material of low permeability and located above an underlying main body of groundwater with which it has no physical connection.
PHYSICAL MODELING	Simulation of atmospheric motion and potential pollutant distribution over a replica of a terrain (styrofoam plates, clay, etc.) to be studied in an enclosed chamber with artificial winds being generated by fans or flowing water.
PICO CURIES (pCi)	10^{-12} curie. A curie is a unit of radioactivity.
POLLUTION ROSE	A graphic representation of the effect of wind direction on average air pollutant concentrations.
ppb	Parts per billion; (W) by weight, (V) by volume.
ppm	Parts per million; (W) by weight, (V) by volume.
ppt	Parts per trillion; (W) by weight, (V) by volume.

QUATERNARY	The geologic period covering the last two or three million years.
RAPTOR	Bird of prey such as a hawk, owl, or eagle.
RECHARGE AREA	A pervious soil or geologic formation through which water may move to replenish the groundwater.
REINJECTION	Process of removing excess condensate from the cooling tower basin and injecting it into the steam reservoir through nonproducing wells.
RESERVE CAPACITY	Backup generating capacity used in the event other generating units are unavailable for service because of forced or scheduled outages or in the event of unforeseen conditions that can affect either the magnitude of the load or system capacity or both.
RIPRAP	Relatively large rock, cobbles, boulders, or rock fragments used to protect a slope from erosion or from sloughing or sliding.
RIPRARIAN	Associated with or adjacent to a permanent or seasonal water source.
RUNOFF	That portion of precipitation on the land that ultimately reaches streams; water from rain or melted snow that flows over the surface.
SCRUBBERS	Devices used to remove contaminants from a gas stream.
SEDIMENTATION	The settling of earthen solids in a liquid.
SEDIMENTATION POND	A pond formed by damming a permanent watercourse to trap sediment eroded from a construction site. Also referred to as a Sediment Basin.
SEISMIC LOADS	Forces which act on a structure during an earthquake.
SEISMICITY	State of being caused by or subject to an earthquake or earth vibrations.
SERPENTINE	A rock or mineral consisting essentially of a hydrous magnesium silicate, usually having a dull green color and often found along fault zones and landslide areas.
SHEAR ZONE	A zone of crushed rock caused by tectonic forces, often in relation to faulting.

SIGNIFICANT	Within the context of the California Environmental Quality Act, "significant" refers to an <u>adverse</u> environmental impact of consequence. Per the National Environmental Policy Act, "significant" impact means any major environmental impact, whether adverse or beneficial.
SIGNIFICANT NOISE SOURCE	A term that refers to a noise level that would be annoying to the normal person and could cause interference with sleep and conversation.
SILICA-CARBONATE	Rock composed largely of magnesium carbonate: quartz, chalcedony, and opal.
SILVICULTURE	The art or procedures of producing and tending a forest and forest trees.
SLOPE	The degree of deviation of a surface from horizontal, measured in a numerical ratio or percentage. The first number is the vertical distance (rise) and the second is the horizontal distance (run), as 2:1 or 200 percent. Expressed in degrees it is the angle of the slope from the horizontal plane with 90° slope being vertical (maximum) and 45° being a 1:1 slope.
SPECIFIC CONDUCTANCE	A physical quantity that measures the readiness with which a medium transmits electricity. Commonly used for expressing the salinity of irrigation waters or soil extracts because it can be directly related to salt concentration. It is expressed in mhos per centimeter (or millimhos per centimeter or micromhos per centimeter at 25° C). Also referred to as electrical conductivity.
STATIS LOAD	Forces which act in a structure during normal conditions (gravity).
STEAM RESERVOIR	A porous and permeable geological structure, underlain by a heat source and overlain by an impermeable caprock, containing steam.
STEAM STACKING	The condition where incoming steam is released to the atmosphere instead of entering the power plant. This condition occurs when a geothermal power plant is not in operation.
STEAM SUPPLIER	Geothermal development firm with which the utility has contracted for the sale and purchase of geothermal steam.
STEAM SUPPLY AREA	Land area necessary to provide an adequate source of geothermal steam for a particular power plant unit.
STEAM SUPPLY FIELD	A geographical area overlying one or more steam reservoirs accessible by conventional drilling technology.

STRETTFORD UNIT	A system of components designed to remove hydrogen sulfide gas from steam and convert it directly to elemental sulfur.
STUDY AREA	Area of variable size which has been individually defined and described for each subject area in which it is used.
SUBSIDENCE	Settling or sinking of land, usually due to withdrawal of natural underground fluids by man.
SURFICIAL	A geological term indicating those materials at or near the surface, e.g., shallow alluvium, colluvium, or residual soils.
SUMP	A pit or reservoir serving as a drain or receptacle for liquids.
TAPLINE	A short electrical transmission line that connects a plant to a main transmission line with no switching facilities at the point of connection.
TECTONIC	Relating to the folding or faulting of the earth's crust.
TERATOGENIC	Those agents which can cause development of abnormal structures in an embryo; development of a severely deformed fetus.
THOUSAND CIRCULAR MILLS (mcm)	A circular mil (cm) is a term used to define cross sectional areas, being a unit of area equal to the area of a circle one mil in diameter. A mil equals one thousandth of an inch.
TOPOGRAPHY	Physical features of a district or region such as are represented on maps; the relief and contour of the land.
TRACER (STUDIES)	Simulation of pollutant transport in actual field conditions through release of predetermined amounts of inert tracer gases and capture of these gases by a bag sampler array to be analyzed by a laboratory for amounts captured.
TRANSMISSION LINE	Structures and conductors that carry bulk supplies of electrical energy from power generating units for system needs. By definition, transmission voltage is 50 kV or above.
TROPHIC LEVELS	A means of categorizing organisms by their position in the food chain. Higher trophic levels are those animals which consume other animals.
TROPOPAUSE	Upper portion of the atmosphere, which extends outward about 7 to 10 miles from the earth's surface.

TURBINE	Rotating engine activated by the reaction or impulse or both of a current of fluid or gas.
ug/m ³	Micrograms per cubic meter.
VENTING	Releasing steam from a pipeline section through valves to the atmosphere.
WATERSHED	A topographically defined area drained by a river/stream or system of connecting river/streams such that all outflow is discharged through a single outlet.
WATER VAPOR	Water substance in vapor form; one of the most important constituents of the atmosphere.
WATT (W)	The amount of work available from an electric current of one ampere at a potential of one volt. 1,000 watts (1 kilowatt) is roughly the amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit per second.
WHEEL ELECTRICITY	Use of the transmission facilities of one utility system to transport power of and for another utility.
WIND ROSE	A graphic depiction of the predominant wind direction and force and relative occurrence of calms.

APPENDIX A

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Geology

Potential Impact	Significance	Source
<u>POWER PLANT FACILITIES</u>		
<u>Hazards</u>		
Slope Instability (e.g. Landslides)	<u>Significant:</u> The major geologic hazard in The Geysers area is slope failure. Sound geotechnical engineering practices should minimize this hazard at the plant site.	AFC, Appendix "A", page 26., and AFC. Table 5.3-1. See Geology section of the EIR for discussion.
Subsidence	<u>Unresolved:</u> Subsidence may occur within geothermal fields, apparently as a result of steam withdrawal. However the magnitude of subsidence is low (2 to 3 cm/yr.) so it should not cause plant operational difficulties.	AFC Table 5.3-1 and Page 5-29
Expansive Soils	<u>Insignificant:</u> Any expansive soils encountered at the plant site should be mitigable.	Good engineering practice.
Differential settlement	<u>Insignificant:</u> Structures that will be placed on materials subject to differential settlement (e.g. embankment material) can be designed to withstand differential settlement.	
Volcanic activity	<u>Insignificant:</u> The last volcanic activity occurred 10,000 or more years ago. The probability of renewed activity during the design-life of the facility is very low.	AFC Appendix "A", Page 26., and AFC Page 5-29

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Geology

Potential Impact	Significance	Source
Cavity collapse	<u>Insignificant:</u> There is no indication of cavities at the proposed site, and subsurface cavities or voids are not expected.	AFC Page 5-29
<u>Impacts</u>		
Unique geologic features	<u>Insignificant:</u> No unique geologic features are apparent at the site.	CEC staff site inspection and AFC page 5-31.
Mineral resources	Insignificant: Other than the geothermal resource there are no significant mineral resources apparent at the plant site.	CEC staff site inspection and AFC page 5-31.
Geothermal resource	<u>Unresolved:</u> The geothermal resource will be impacted but because many characteristics of the steam reservoir are unknown CEC staff cannot determine the rate of depletion.	See Geology Section of EIR.
<u>STEAM FIELD (wells, well pads, roads, and pipelines)</u>		
<u>Hazards</u>		
Slope Instability (e.g. landslides)	<u>Significant:</u> The geologic map of the leasehold show several landslides; therefore, considerable care will have to be taken in siting and constructing the wells, well pads, roads, and pipelines.	AFC Figure 5.3-2 See geology section of EIR for discussion.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Geology

Potential Impact	Significance	Source
Subsidence	<u>Insignificant:</u> Subsidence may occur within the steam field however the magnitude of the subsidence is not expected to cause damage in the steam field.	AFC Page 5-29
Volcanic activity	<u>Insignificant:</u> The last volcanic activity occurred 10,000 or more years ago. The probability of renewed activity during the design-life of the facility is very low.	AFC Appendix A, Page 26 and AFC Page 5-29.
<u>Impacts</u>		
Unique geologic features	<u>Insignificant:</u> No unique geologic features are apparent within the leasehold.	CEC staff site inspection and AFC Page 5-31.
Mineral resources (other than the geothermal steam)	<u>Insignificant:</u> There are no significant mineral resources apparent within the leasehold.	CEC staff site inspection and AFC Page 5-31.
<u>Transmission Line</u>		
Slope Instability (e.g. Landslides)	<u>Insignificant:</u> No active or inactive landslides have been delineated within the proposed transmission line corridors. However, the potential for landslides exists if improper engineering techniques are employed in the construction of the facility.	AFC Page 8-5

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Geology

Potential Impact

Significance

Source

Commercial and noncommercial geologic resources

Insignificant: No geologic resources should be lost due to construction of the transmission facility.

CEC staff inspection.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Seismic Hazards

Potential Impact	Significance	Source
<u>POWER PLANT FACILITIES</u> <u>Hazard</u> Seismic shaking/Fault rupture/Lurching/Liquefaction	<u>Insignificant:</u> Good siting design and construction practice will prevent unacceptable damage. Liquefiable soils and unstable slopes are not constraints at the proposed site.	AFC, pg. 5-29; Table 5.3-1; Appendix C, pg.26 AFC, pg. 5-28; Table 5.3-1; Appendix C, pg.26
278 <u>STEAM FIELD</u> <u>Hazard</u> Seismic shaking/Liquefaction. Fault rupture/subsidence	<u>Insignificant:</u> Facilities not sensitive to shaking and easily repaired (except wells), Liquefiable soils not present in leasehold. <u>Unresolved:</u> Movements (tectonic or differential subsidence) along faults may rupture wells, resulting in steam blowouts if rupture is near ground surface.	CEC Staff Opinion CEC Staff Opinion; AFC, pgs. 5-27; Appendix C, pg. 26
<u>TRANSMISSION LINES</u> <u>Hazard</u> Seismic shaking/Liquefaction	<u>Insignificant:</u> Facilities not sensitive to shaking and easily repaired. Liquefiable soils not known to be present.	CEC Staff Opinion

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Seismic Hazards

Potential Impact

Significance

Source

TRANSMISSION LINES - continued

Fault rupture/subsidence

Insignificant: Good siting and design provides adequate mitigation.

CEC Staff Opinion

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Soils

Potential Impact

Significance

Source

WELL FIELD

Soil erosion and compaction due to construction of:

1. Roads

Significant

The loss of soil on 3 acres of road way would be a minimal impact except for the fact that the disturbance is located across the head waters of both Anderson and Gunning Creeks on soil series characterized as moderate to very highly erodible. Furthermore, Anderson and Gunning Creeks supply water for the community of Anderson Springs. High sediment discharge from Occidental construction site could exert a very detrimental impact on this water supply.

Review AFC Sections 1.2.3.1, 1.2.4 and 1.2.6 and environmental assessment reports prepared by the U.S. Geological Survey along with field observations by the staff.

2. Work Camps

Insignificant

Minimal impact

3. Drill Pads

Significant

The loss of 5.6 acres of native soils is modest in comparison to the 550 acre leasehold. However, the impact will not be in proportion to the area denuded but rather to the vulnerable location of the pads in the upper drainage of both Anderson and Gunning Creeks. Impacts of

(continued)

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Soils

Potential Impact	Significance	Source
<p>3. Drill Pads (continued)</p> <p>4. Pipeline Corridors</p> <p>Potential changes in soil chemistry from discharge of geothermal fluids, spills of maintenance chemicals, disposal of drilling muds, pipeline leaks, venting, etc.</p> <p>Erosion potential due to the discharge of geothermal fluids by venting or pipeline rupture.</p>	<p>Construction activities which disturb the natural soil cover could be significant.</p> <p><u>Significant</u> Again, the significance of the impact is dependent on the location of the pipeline route across the top of both the Anderson and Gunning Creek Watersheds and not the area disturbed viz. 2-7 acres. The impact on the Anderson Springs water system could be significant.</p> <p><u>Unresolved</u> Significance depends on frequency and duration of such events and could vary from severe to inconsequential. The buffering capability of the soil enhances its ability to receive and attenuate the impact of chemicals spilled upon it.</p> <p><u>Significant</u> Although such events are infrequent, their impacts could be severe and long lasting.</p>	<p>AFC Figure 1.2-2 and field observations of the Anderson Springs Water Company intakes in Gunning Creek.</p> <p>"Ecoview EIR for PG&E Geysers 17", Appendix XII, Listing of Pollution Incidents at the Geysers Geothermal Field by the North Coast Regional Water Quality Control Board.</p> <p>Same as preceding item.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Soils

Potential Impact

Significance

Source

Erosion and sediment transport below waste sumps and settling basins.

Significant

The discharge of relatively clear water from riser type outlets could greatly increase the sediment transport capacity of the releases. Discharge of such waters could greatly increase the scouring and bank undercutting of downstream channels.

Staff field observations Berkshire County Regional Planning Commission and Curran Associates, Inc., Evaluation of Power Facilities: A Reviewers Handbook, April 1974.

POWER PLANT

Disturbance of soils during site preparation and construction of the power plant and related facilities.

Significant

The displacement of 7.4 acres of soil and native vegetation is quantitatively small in comparison to the 550 acre leasehold. However, the scalping and commingling of top soil with subsoil, compaction and loss of plant nutrients could adversely affect the establishment of vegetation on the site and adjacent land. Unless an erosion control program is initiated in conjunction with construction, there is a potential for significant adverse impacts to the soil resource.

AFC, p. 5-18, Section 5.2.1.2
AFC, p. 5-34, Section 5.4.3 and 5.4.4
p. 5-63, Section 5.5.6.1
AFC, Appendix D: Soil Data

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Soils

Potential Impact	Significance	Source
Increased erosion potential due to construction activities.	<p><u>Significant</u></p> <p>The replacement of pervious soils and plant cover with buildings and impervious asphalt parking lots will increase the volume and concentrate the discharge from 7.4 acres. In spite of erosion control structures and re-seeding there will be the potential for increased erosion and sediment transport down Anderson Creek.</p>	AFC, p. 1-13, Section 1.3.6; Figure 1.3-3; Figure 1.3-4; p. 5-18, Section 5.2.1.1 Field Observations.

INITIAL ENVIRONMENTAL IMPACT EVALUATION
STEAMFIELD

Environmental Category - Hydrology

Potential Impact	Significance	Source
Water Supply	<p><u>Unresolved:</u></p> <p>The following stipulation appears in the Lake County Use Permits for Drill Pad B:</p> <p>"Any water for construction or maintenance of site "B" and its road shall be from sources other than Anderson or Gunning Creeks, their tributaries, or springs in the area unless such water can be obtained without hazard to the biota or to the drinking water supplies of Anderson Springs. These sources should not be used without first obtaining approval from the Anderson Springs watermaster, and the DCM for geothermal in consultation with the U.S. Bureau of Land Management".</p> <p>Inspite of those rather strong quarantees, the people of Anderson Springs remain unconvinced that Occidental will not:</p> <ol style="list-style-type: none"> 1. extract groundwater from exploratory drill holes on their leasehold or 2. receive water from an Aminoil pond supplied by a riparian diversion from Gunning Creek. 	<p>U.S. Department of Interior, Geological Survey "Environmental Assessment 131-81. Occidental Geothermal, Inc. Site B", Typical Approval Conditions, December 1980.</p> <p>County of Lake, Use Permit for Occidental Geothermal Site "B".</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION
STEAMFIELD

Environmental Category - Hydrology

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Potential Impact	Significance	Source
<p><u>Water Quality</u></p> <p>Degradation of the waters of Anderson and Gunning Creek due to on-site erosion and sediment transport and deposition.</p>	<p><u>Significant:</u> Erosion and subsequent deposition of sediment in Anderson and Gunning Creeks has the potential of impairing and interfering with beneficial water uses, e.g., irrigation, recreation and municipal uses.</p>	<p>U.S. Dept. of Interior, Geological Survey, <u>Environmental Assessment 131-81, Occidental Site B, 1981</u></p> <p>Anderson, Henry W., "Sediment Deposition in Reservoirs Associated with Rural Roads, Forest Fires, and Catchment Attributes", <u>Proc. Symp. Man's Effect on Erosion and Sedimentation, UNESCO (Paris, Sept. 9-12, 1974), Int. Assoc. Hydrol. Sci. Publ. 113, p. 87-95 1974</u></p> <p>Anderson, Henry W., "Reservoir Sedimentation Associated with Catchment Attributes, Landslide Potential, Geologic Faults and Soil Characteristics", <u>Proc. Third Inter-agency Sedimentation Conf. Symp. I "Sediment Yield and Sources", (Denver, Colorado, March 22-25, 1976) Water Resources Council p. 35-46 1976.</u></p>
<p>Commingling and contamination of the surface waters of Anderson or Gunning Creeks due to spills of deleterious materials caused by pipeline ruptures, mechanical failures; errors in human judgement and vehicular accidents connected with geothermal development.</p>	<p><u>Significant:</u> "The Geysers" KGRA has a long history of spill incidents involving local streams due to geothermal development.</p>	<p>California Energy Commission, <u>Cumulative Biological Impacts of the Geysers Geothermal Development, "Appendix D - Pollution Incidents", to be released June 1981.</u></p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION
STEAMFIELD

Environmental Category - Hydrology

Potential Impact	Significance	Source
<u>Flood Hazard</u>	<p><u>Unresolved</u></p> <p>Drill Pad "C" is partially located in an arroyo tributary to Anderson Creek. The drill pad fill has an upstream drainage of seven acres which could generate a peak flow of 15 ft³/sec in a 1:100 storm. During a 6-hour storm two acre feet of water would have to be handled by the drill pad drainage system. Depending on the design and sizing of the drainage system portions of the sight might be vulnerable to 1:100 flooding.</p> <p><u>Insignificant</u></p> <p>Drill Pads A, B, and D are located on ridges or noses of ridges with little upstream drainage and well above Anderson and Gunning Creeks.</p> <p>Selected routes for roads, transmission lines and steam pipelines indicate limited vulnerability to overflow and/or overland flooding.</p>	<p>AFC. Figure 1.2-2; Section 5.2.1.2, p. 5-18; Section 5.2.3, p. 5-21, Appendix C, Section IX, p. 27.</p> <p>Staff calculations and field observations.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION
POWER PLANT SITE

Environmental Category - Hydrology

Potential Impact	Significance	Source
<p><u>Water Supply</u></p> <p>For construction purposes.</p>	<p><u>Unresolved</u></p> <p>Although the approximately 14 acre feet necessary to be trucked in is small, there is a question in the mind of the local residents that it might impact Gunning Creek. In spite of the fact that federal and local permits discourage the use of water from Anderson and Gunning Creek there is a concern that the water needed for construction will be taken from a pond filled by a diversion from Gunning Creek. The water is apparently diverted on riparian properties above Ford Flat Road and conveyed to a pond belonging to Aminoil below Ford Flat Road.</p>	<p>AFC P. 1-3.4, Section 1.4.7.4. Dept. of the Interior, U.S. Geological Survey, <u>Special Conditions Added to Occidental Geothermal's Plan of Operation for the Construction of Drill Pad "B"</u>, January 9, 1981.</p> <p>County of Lake, Use Permit: <u>Occidental Geothermal Site "B"</u>, U.P. 80-25, issued January 19, 1981.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION
POWER PLANT SITE

Environmental Category - Hydrology

Potential Impact	Significance	Source
For domestic, in-plant and landscape irrigation uses	<p><u>Unresolved</u></p> <p>The eight gallons per minute (13 AFY) estimated by the applicant is a minimal amount. The impact will be insignificant provided that none of this water comes from the Anderson or Gunning Creek watersheds.</p>	AFC p. 1-34, Section 1.4.7.4
For condensor cooling	<p><u>Insignificant</u></p> <p>The use of spent steams as a coolant will have no influence on local surface or groundwater supplies. Importation of water for the initial filling of the cooling tower basin, if from outside the immediate vicinity, will exert no adverse influence on local water resources.</p>	AFC p. 1-33, Section 1.4.7.1

INITIAL ENVIRONMENTAL IMPACT EVALUATION
POWER PLANT SITE

Environmental Category - Hydrology

Potential Impact	Significance	Source
<u>Water Quality</u> Commingling and contamination of surface and/or groundwater	<u>Insignificant</u> No regional groundwater aquifers of significant yield have been reported in the rock formations of the Mayacmas Mountains in the Geysers area. Therefore, there is very little groundwater to contaminate.	AFC Section 5.2.1.4.1, p. 5-19 State of California, Department of Water Resources, Bulletin No. 118-4 <u>Evaluation of Groundwater Resources: Sonoma County, Volume 1: Geologic and Hydrologic Data</u> , December 1975.
Plant sanitary wastes	<u>Insignificant</u> The waste water discharged from these facilities will be piped to a common package secondary sewage treatment plant. The treatment plant will separate the solids from the waste water and provide adequate treatment to permit the waste water to be added to the reinjected excess condensate.	AFC Section 1.4.7.6, page 1-36
Oily wastes	<u>Insignificant</u> Approximately 100 gal/yr of oily wastes will be generated from minor leaks and through routine maintenance procedures. The waste will be stored on-site and disposed of, either by an approved oil reprocess or a suitable dump site.	AFC Section 1.4.8.1, page 1-36

INITIAL ENVIRONMENTAL IMPACT EVALUATION
POWER PLANT SITE

Environmental Category - Hydrology

Potential Impact	Significance	Source
Excess circulating water	<u>Insignificant</u> Will be combined with the liquid effluent from the sewage treatment plant and returned to the steam field for injection.	<u>AFC</u> , Section 1.4.8.1, page 1-36
Trash and inert construction and maintenance wastes	<u>Insignificant</u> Inert wastes produced during construction, maintenance and operation of the plant will consist of such materials as excess concrete, scrap lumber, and paper and plastic packaging. These wastes will be hauled to a licensed Class II landfill.	<u>AFC</u> , Section 1.4.8.2, page 1-36
Sewage sludge	<u>Insignificant</u> Sludge will be removed from the sewage treatment facility approximately once a year by a licensed commercial sewage disposal service, which will truck it to a licensed Class II-1 landfill.	<u>AFC</u> , Section 1.4.8.2, page 1-36

INITIAL ENVIRONMENTAL IMPACT EVALUATION
POWER PLANT SITE

Environmental Category - Hydrology

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Potential Impact	Significance	Source
Chemical Spills	<p><u>Insignificant</u></p> <p>Areas where chemicals may be present, such as chemical storage, chemical processing, transformers, and fuel oil storage will be paved and curbed. The curbs will be designed to contain complete spill.</p> <p>Chemicals and wastes will be hauled by licensed carriers in containers conforming to applicable sections of CFR Title 49.</p> <p>In the event of an uncontained spill or leak causing pollution of local waters, qualified spill clean-up contractors will be hired as needed to assist in clean-up.</p>	<p><u>AFC</u>, Section 5.2.4, page 5-22</p> <p><u>AFC</u>, p. 5-23</p> <p><u>AFC</u>, p. 5-23</p>
<u>Flood Hazard</u>	<p><u>Insignificant</u></p> <p>Flooding of the site will not be a problem. The site is located along a ridgeline, at the headwaters of Anderson and Gunning Creek, with little upstream drainage area.</p>	<p>AFC Section 5.2.1.2 Flooding, p. 5-18 Figure 1.2-2; Section 5.2.3, page 5-21; Appendix C, Section IX, page 27.</p> <p>Staff calculations and field observations.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION
TRANSMISSION LINES

Environmental Category - Hydrology

Potential Impact	Significance	Source
<u>Water Supply</u>	<p><u>Insignificant</u></p> <p>The amount of water required for the construction of 3 to 4 towers and 2,300 feet of new access roads would be clearly insignificant.</p>	AFC, Section 8.1, page 8-1; Figure 8.1-2. Staff determination.
<u>Water Quality</u>	<p><u>Insignificant</u></p> <p>Because of the short length of road and limited number of towers the potential for impacting water quality is insignificant in time and area disturbed.</p>	AFC, Section 8.1, page 8-1; Figure 8.1-2. Staff determination.
<u>Flood Hazard.</u>	<p><u>Insignificant</u></p> <p>The placement of towers on ridges and noses of ridges eliminates their vulnerability to either stream or overland flooding.</p>	AFC, Figure 8.1-2. Staff determination.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Biological Resources

Potential Impact	Significance	Source
<u>Steam Field and Steam Supply Lines</u>		
Vegetation damage and destruction	<u>Insignificant</u> ; losses will result from construction of roads, well pads, and other access corridors.	AFC Figure 1.2-2
Potential loss of agricultural production	<u>Insignificant</u> ; no agricultural production occurs within the leasehold or immediately adjacent lands.	AFC Figure 5.8-1
Potential for harm to flora and fauna from liquid and gaseous effluents discharged during operation of geothermal facilities	<u>Potentially significant</u> ; H ₂ S concentrations associated with well venting have not been disclosed. High concentrations would be detrimental to surrounding vegetation.	EA (Environment assessment for well pad B, USGS, 1980) P. 5
Loss of wildlife habitat or significant habitat components	<u>Significant</u> ; losses will result from construction of roads, etc.; erosion may impact waterways and their associated aquatic organisms. Impacts can be mitigated.	EA P. 6
Disturbance of wildlife by human activity and noise	<u>Currently assumed to be insignificant.</u>	Leitner, 1978

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Biological Resources

Potential Impact	Significance	Source
Hazards to fish and wildlife from sumps, disposal of drilling muds, releases of geothermal fluids, etc.	<u>Insignificant</u> ; mitigated by U.S.G.S permit conditions.	U.S.G.S. permit for well pad B conditions 2 and 11; permit for well pad D condition B.
Creation of new habitat features and availability of new habitat areas after abandonment	<u>Unresolved</u> ; further information required.	
Potential for loss of flora and fauna from fire	<u>Insignificant</u> ; vegetation on site is "fire-adapted" and should be burned on a long-term rotational basis. Brush management practices will result in reduced fire suppression control costs, habitats loss, and the soil erosion impacts to aquatic habitats which would be associated with wildfires.	AFC; CEC experience in Geysers KGRA
Loss of vegetation (native or agricultural) and wildlife habitat (food cover, nesting locations, breeding ground, winter ranges, etc.), resulting from construction	<u>Significant</u> ; construction will result in the loss of important wildlife habitat associated with the diverse vegetation types of the site. Impacts can be mitigated.	EA P. 16
Increase fire hazard caused by workmen and equipment resulting from construction	<u>Significant</u> if fire prevention measures are not adopted and enforced by CDF. Brush management techniques need to be incorporated to mitigate.	CEC experience in KGRA

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Biological Resources

Potential Impact	Significance	Source
<u>Power Plant and Facilities</u>		
Potential loss of flora and fauna related to the increased fire hazard caused by operation and maintenance of the facility	<u>Insignificant</u> ; biota of region fire-adapted.	CEC staff experience in KGRA
Potential for harm to flora and fauna from liquid and gaseous effluents discharged during operation of geothermal facilities	<u>Significant</u> ; there is a substantial probability of cooling tower drift resulting in foliar damage and ultimately loss of immediate surrounding vegetation.	AFC P. 5-61
Potential loss of agricultural production	<u>Insignificant</u> ; no agricultural production occurs on the leasehold or immediately adjacent lands.	AFC Figure 5.8-1
Change in species composition (both floral and faunal) due to habitat changes (e.g., degradation of water quality) resulting from construction	<u>Potentially significant</u> ; the impact of habitat loss has not yet been determined for some important wildlife species, (i.e., ringtail); severe erosion and stream sedimentation would be detrimental to aquatic organisms.	AFC Pp. 5-19, 5-55, 5-56, 5-57

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Biological Resources

Potential Impact	Significance	Source
Potential harm to vegetation and wildlife from the degradation of water quality from wastewater systems	<u>Insignificant</u> ; mitigation proposed to retain spills on-site	AFC Pp. 1-10, 5-22, 5-23
Permanent loss of vegetation and wildlife habitat due to project facilities		
- Loss or displacement of wildlife supported by the habitat	<u>Insignificant</u> ; losses have been identified but will be reduced by proposed mitigation measures.	AFC Pp. 5-56, 5-60, 5-66
- Loss of rare, endangered, unique or unusual species of plants and wildlife, communities or habitats	<u>Unresolved</u> ; further information required.	Experience
Loss of wildlife from construction activities from lack of available habitat after displacement	<u>Insignificant</u> ; habitat loss has been identified. Mitigation measures have been proposed which will reduce impacts.	AFC Pp. 5-56, 5-66
Direct loss of wildlife from construction activities:		
- Loss of aquatic communities if a stream is relocated	<u>Undetermined</u> ; spring may be lost or altered; no mitigation has been proposed.	AFC Figure 1.2-2 and 5.5-3
- Loss of aquatic organisms (fresh water)	<u>Undetermined</u> ; further information required.	
Loss of rare, endangered, unique, or unusual species or habitat resulting from construction activities	<u>Undetermined</u> ; further information needed.	

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Biological Resources

Potential Impact	Significance	Source
Accumulation of harmful substances in some species due to uptake of pesticides, herbicides, construction chemicals, etc.	<u>Insignificant</u> ; mitigations have been proposed to contain all harmful substances on project site.	AFC P. 5-22
Change in wildlife species composition, species diversity and species number in vicinity of generating facility	<u>Insignificant</u> changes will occur.	Experience, PGandE, 1977
Deleterious effects on aquatic organisms and other wildlife from surface water contamination from cooling tower or pond drift or cooling pond leakage	<u>Insignificant</u> ; no significant effects have been identified. Mitigation measures have been proposed to cover accidental spills.	AFC Pp. 5-22 and 5-23 High probability of spill, some losses have occurred.
297 <u>Transmission Lines</u>		
Vegetation damage and destruction	<u>Insignificant</u> ; preferred route will result in loss of only small amounts of vegetation for tower pads. No new access roads are needed.	AFC P. 8-2
Loss of wildlife habitat or significant habitat components	<u>Insignificant</u> ; areas of disturbance is extremely limited and occurs in common habitat types.	AFC Pp. 8-3 and 8-4

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Air Quality

Potential Impact	Significance	Source
<u>WELL FIELD</u>		
Change in local meteorological conditions due to heat emissions, or site preparation and construction.	<u>Insignificant:</u> Emission are small and site preparation and construction are temporary.	CEC Staff Opinion
Release of primary and secondary pollutants.	<u>Insignificant:</u> Stacking emissions will be controlled by turbine bypass system.	CEC Staff Opinion
<u>POWER PLANT</u>		
Change in local meteorological conditions due to site preparation and construction.	<u>Insignificant:</u> Site preparation and construction are temporary.	CEC Staff Opinion
Creation of aerial dust during construction.	<u>Insignificant:</u> Roadways and site to be wetted during construction.	Occidental Geothermal Plant #1 AFC, Section 9.
Emissions of air pollutants from construction equipment and vehicles.	<u>Insignificant:</u> Construction activities are temporary; pollutants will dissipate.	CEC Staff Opinion
Meteorological effects from cooling towers and addition of water droplets containing cooling system chemicals to the air from wet cooling towers.	<u>Insignificant:</u> Some fogging for about 1-mile radius, then dissipation. Cooling tower design will mitigate the effects.	Occidental Geothermal Plant #1 AFC, Section 5.1.
Emissions of primary pollutants may interfere with the maintenance or the attainment of ambient air quality standards.	<u>Insignificant:</u> The incremental impact of the project will not cause a violation of the ambient air.	Occidental Geothermal Plant #1 AFC, Section 5.1.
Cumulative impacts of the proposed project and other geothermal projects in the site area may result in a violation of the ambient air quality standard for H ₂ S.	<u>Unresolved:</u> The solution to this concern is pending the LCAPCD Determination of Compliance as of 4/28/81.	Occidental Geothermal Plant #1 AFC, Section 5.1 and Appendix B; and Staff Analysis.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Air Quality

Potential Impact	Significance	Source
<p><u>TRANSMISSION LINES</u></p> <p>Production of oxidants, ozone and NO_x by energized lines.</p> <p>Contamination of insulators by particulates and sulfur dioxide in the air.</p>	<p><u>Insignificant:</u> Background level are well below ambient standards. Transmission line emission are minimal.</p> <p><u>Insignificant:</u> Plant emission of particulate and sulfur dioxide are minimal.</p>	<p>CEC Staff Opinion</p> <p>CEC Staff Opinion</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Noise

Potential Impact	Significance	Source
<p><u>WELL FIELD</u></p> <p>Exposure to noise in excess of 90 dBA for 8 hours for workers or in excess of 55 dB L_{dn} to sensitive environmental receptors.</p> <p><u>POWER PLANT</u></p> <p>Exposure to noise during construction in excess of 90 dBA for 8 hours for workers or in excess of 55 dB L_{dn} to sensitive receptors.</p> <p>Exposure during operation of power plant to noise in excess of 90 dBA for 8 hours for workers or in excess of 55 dB L_{dn} to sensitive receptors.</p>	<p><u>Insignificant:</u> Project noise levels are below standards.</p> <p><u>Insignificant:</u> Project noise levels are below standards, the Applicant will supply hearing protection to mitigate exposure to workers.</p> <p><u>Insignificant:</u> Project noise levels are below standards, the Applicant will supply hearing protection to mitigate exposure to workers.</p>	<p>Occidental Geothermal Plant #1 AFC, page 1-23 and Section 5-6.</p> <p>Occidental Geothermal Plant #1 AFC, page 1-23 and Section 5-6.</p> <p>Occidental Geothermal Plant #1 AFC, page 1-23 and Section 5-6.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Wastes

Potential Impact	Significance	Source
<p><u>STEAM FIELD</u></p> <p>Nontoxic drilling muds will be land filled near the well drilling pads.</p> <p><u>POWER PLANT</u></p> <p>Rubbish produced during normal plant operation will be hauled away periodically by a commercial collection service.</p>	<p><u>Insignificant:</u> As long as the muds are not eroded into surface waters.</p> <p><u>Insignificant:</u> As long as the waste is hauled to a properly licensed disposal site.</p>	<p>RWQCB waste discharge requirements for well field.</p> <p>CEC Staff Opinion.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Health

Potential Impact	Significance	Source
<p><u>POWER PLANT</u></p> <p>Emissions incurred during construction may present a health hazard to workers or the public.</p> <p>Emissions from generating operation may present a health hazard to workers or the public.</p> <p>Cumulative emissions from generating operation may present a health hazard to workers or the public.</p>	<p>Workers: <u>Potentially significant, mitigable.</u> Compliance with occupational health standards and requirements should ensure adequate protection of worker health.</p> <p>Public: <u>Insignificant</u> - Emissions from construction equipment and dust should not increase ambient pollutant concentrations in the nearby communities, or in the air basin, to levels which would affect public health.</p> <p>Workers: <u>Potentially significant, mitigable.</u></p> <p>Public: <u>Unresolved</u></p> <p>Workers: <u>Potentially significant, mitigable.</u></p> <p>Public: <u>Unresolved</u> - Resolution is pending Determination of Compliance submittal by Lake County Air Pollution Control Officer.</p>	<p>CEC Staff Analysis</p> <p>CEC Staff Analysis</p> <p>See Public Health Attachments #1 & #2.</p> <p>See Public Health Attachments #1 and #2.</p>
<p><u>STEAM FIELD AND SUPPLY LINES</u></p> <p>Emissions during normal operation may present a health hazard to workers or the public.</p>	<p>Workers: <u>Potentially Significant, mitigable.</u></p>	<p>See Public Health Attachments #1 & #2.</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Health

Potential Impact	Significance	Source
<p>Emissions during stacking operation may present a health hazard to workers or the public.</p> <p>303 Potential degradation of water quality may present a health hazard to the public.</p> <p><u>HAZARDOUS WASTES</u></p> <p>Emissions and spills of hazardous pollutants from power plant sludge and abatement chemicals may present a health hazard to workers or the public.</p>	<p>Public: <u>Insignificant</u> - Normal operation (excluding stacking) of steam field contributes 5-6% of the total H₂S emissions in the Geysers KGRA. The resulting potential impact on ambient pollutant concentrations in populated areas is insignificant relative to total power plant emissions.</p> <p>Workers: <u>Potentially significant, mitigable.</u></p> <p>Public: <u>Unresolved</u></p> <p><u>Potentially Significant, mitigable.</u></p> <p>Workers: Potentially significant, mitigable. Compliance with occupational health standards and requirements should ensure adequate protection of worker health.</p> <p>Public: <u>Potentially significant, mitigable.</u> Compliance with hazardous waste disposal and hazardous chemical transport regulations should ensure adequate protection of public health.</p>	<p>SRI International, May 1977. Environmental Analysis in the Geysers Region Vol. 1: Summary. SRI Project EGC-5554, CEC Consultant Report P500-77-005.</p> <p>See Public Health Attachment #1. See Public Health Attachments #2 & #3.</p> <p>See Water Quality.</p> <p>CEC Staff Analysis</p> <p>CEC Staff Analysis</p>

HEALTH AND SAFETY IMPACTS MATRIX

Attachment No. 1

Potential Impact: Emissions from steam field and power plant operation may present a health hazard to workers.

A. Hydrogen Sulfide and Benzene: Potentially Significant, Mitigable

The Applicant must comply with Cal/OSHA occupational health and safety requirements (California Administration Code, Title 8, Industrial Relations, Chapter 4). Staff recommends that the Applicant be required to develop a worker health program with the assistance of the Cal/OSHA Consultation Service to ensure compliance with these requirements during power plant operation.

B. Radon-222: Potentially Significant, Mitigable

Although emissions may at times exceed the California emission standard for ^{222}Rn , workers' doses can be controlled by the amount of time spent in the affected work area (LFE, 1975; Anspaugh, 1978). Staff and the Department of Health Services recommend that the Applicant be required to implement a radiological monitoring/reporting plan approved and enforced by the Department of Health Services, Radiologic Health Section (DHS/RHS) (CAC, 1976; Vold, letter, February 19, 1981). This program should ensure adequate protection of worker and public health.

C. Ammonia, Arsenic, Boron, Mercury, ADA and Vanadium: Insignificant

Emission of these pollutants is not expected to produce levels exceeding occupational standards or recommended safe levels of exposure for workers. However, NIOSH is currently investigating occupational health hazards at geothermal power plants in the Geysers KGRA.

Attachment No. 2

Potential Impact: Emissions from the steam field and power plant operations may present a health hazard to the public.

A. Hydrogen Sulfide: Unresolved

The Lake County Air Pollution Control Officer has not made a determination of compliance. Few studies have been conducted to determine health effects from low-level, long-term exposure to hydrogen sulfide (H_2S) at levels likely to be encountered in the communities surrounding the plant; thus, this is a controversial issue (NAS, 1979).

B. Radon-222: Potentially Significant, Mitigable

See Attachment No. 1, Radon-222.

Attachment No. 2 (continued)

C. Ammonia, Arsenic, Benzene, Boron, Mercury, Silica, ADA, and Vanadium:
Unresolved

CEC staff recommends that the Applicant be required to conduct a limited-term preoperational monitoring study to establish baseline ambient air data, along with an operational monitoring study, for ammonia, mercury, arsenic, boron, benzene, silica, and vanadium. CEC staff also recommends that the Applicant be required to periodically monitor the steam supply for ammonia, arsenic, boron, benzene, silica, H₂S, and present noncondensibles.

Attachment No. 3

Stacking operations are a minor source of environmental pollutants, typically releasing to the atmosphere 4.4 percent of the total steam produced in PGandE Units in 1977 at The Geysers KGRA (Accurex, 1980). The Applicant has proposed two independently operating turbines, each with a turbine bypass, which the Applicant expects to greatly reduce the need for steam stacking. The bypassed steam will be condensed and the H₂S will be treated by the Stretford unit and the condensate treatment system (AFC, p. 1-22). However, the Applicant's ability to comply with stacking emission allowances (EPA's New Source Review and LCAPCD Rule 421-B) has yet to be determined.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Safety

Potential Impact	Significance	Source
<u>POWER PLANT</u>		
Possibility of accidents associated with construction of power plant facilities.	<u>Insignificant</u> : Isolated construction location, with a temporary work force, Cal-DOSH requirements in place.	Oxy #1 AFC Sec. 9, Sec. 6.3; CEC Staff Analysis.
Possibility of accidents associated with use of explosives, heavy equipment operation.	<u>Insignificant</u> : Limited use of heavy equipment. No blasting expected. Cal-DOSH requirements in place.	Oxy #1 AFC Sec. 9, Sec. 6.3; CEC Staff Analysis.
Possibility of accidents associated with operation and maintenance of generation system equipment.	<u>Insignificant</u> : Control room will monitor plant deviations, equipped with automatic and manual shutdowns.	Oxy #1 AFC Sec. 1.4.5.
Possibility of security problems associated with general operations and maintenance of the plant.	<u>Insignificant</u> : Isolated location, relatively low hazard level, automatic and manual shutdown provisions. Standard security to be provided.	Oxy #1 AFC Sec. 1.4.5., Sec. 9., CEC Staff Analysis.
<u>STEAM FIELD AND SUPPLY LINES</u>		
Possibility of accidents associated with transportation systems constructed as a direct adjunct to the power plant (example: new supply road).	<u>Insignificant</u> : 2 miles of road needed as access to four well pads, 250 yds to the main ridge line road. All construction will be within the leasehold, isolated area, Cal-DOSH requirements in place.	Oxy #1 AFC Sec. 1.2.6, Sec. 1.3.1.
Possibility of accidents associated with well drilling and steam or hot water extraction.	<u>Insignificant</u> : No unusual risk or hazard.	CEC Staff Opinion.
Emissions may be caused by accident hazard during well operations.	<u>Insignificant</u> : There has been only a single incident in the KGRA where a well failed and steam escaped freely.	CEC Staff Analysis: Geysers 16 EIR.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Transportation

Potential Impact	Significance	Source
<u>WELL FIELD</u> Impact on transportation system (roads).	<u>Significant:</u> Cumulatively with projects.	See Transportation section of EIR
<u>POWER PLANT</u> Impact of construction traffic on transportation system (roads).	<u>Significant:</u> Local roads not adequate to handle large traffic increases. Cumulative with other projects.	See Transportation section of EIR
307 Impact of increased heavy traffic on condition of roads and structures.	<u>Significant:</u> Particularly cumulatively with other projects.	See Transportation section of EIR
Impact of operational traffic, including waste disposal, on transportation system (roads).	<u>Significant:</u> Cumulatively with projects.	See Transportation section of EIR

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category

Socioeconomics

Potential Impact

Significance

Source

POWER PLANT

Project area will experience increased employment and income directly attributable to construction of power plant and related facilities (primary employment).

Power plant construction will compete for workers with other projects or existing economic sectors.

Project area will experience increased employment and income directly attributable to operation and maintenance of power plant.

Project area population will increase due to increases in direct and indirect employment.

Possible changes in community structure, lifestyle.

Insignificant - Total peak employment will be 230 workers.

Insignificant - Historical unemployment rates for region exceed those of the state as a whole.

Insignificant - Only 20 employees required for operation phase.

Insignificant - If applicant supplies commuter service, total population increase will be dispersed throughout the four county area.

Significant - Cumulative impact is potentially significant in Lake Co.

Insignificant - Total population is small relative to existing population.

AFC, p. 5-96

AFC, p. 5-87

AFC, p. 5-92

AFC, p. 5-88 and 5-92

AFC, p. 5-88 and 5-92

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category Socioeconomics

Potential Impact	Significance	Source
<p><u>POWER PLANT (Cont)</u></p> <p>Housing units will be required to accommodate households of construction and secondary workers.</p> <p>Operation and maintenance of power plant may result in new households in project area.</p> <p>Presence of power plant may diminish employment in other sectors.</p> <p>Change in basic economic activities of affected region, primarily rural/agricultural and recreation areas.</p> <p>Impact of additional population on adequacy of commercial services.</p> <p><u>WELL FIELD</u></p> <p>Population increase attributable to development of the geothermal resource required for the proposed facilities (direct and induced immigration).</p>	<p><u>Insignificant:</u> Total population impact is small due to dispersion of new workers throughout the four Co. area.</p> <p><u>Significant</u> - Cumulative effects will strain housing supplies in Lake Co.</p> <p><u>Insignificant</u> - Operating workforce is only 20 employees.</p> <p><u>Insignificant</u> - No other sector will be affected with regard to employment for proposed facility.</p> <p><u>Insignificant</u> - Project is continuation of existing geothermal development in the areas.</p> <p><u>Insignificant</u> - Population increase is small relative to that already in the area.</p> <p><u>Insignificant</u> - Workers migrate from site to site. (Addition of further crews would contribute to adverse cumulative impacts.)</p>	<p>AFC, p. 5-91</p> <p>AFC, p. 5-92</p> <p>AFC, p. 5-87</p> <p>AFC, p. 5-83</p> <p>AFC, p. 5-88 and 5-92</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category Socioeconomics

Potential Impact

Significance

Source

WELL FIELD (Cont)

Impact on supply of labor available to other sectors in the local economy.

Insignificant - Historical unemployment rates are high, indicating adequate supply of labor. AFC, Table 5.8-4 and 5.8-5

TRANSMISSION LINES

Population and housing effects due to construction of transmission lines.

Insignificant - Staff assumes that the construction of the transmission line requires a similar workforce as for the SMUDGE transmission line. A single 10 person crew will be needed for SMUDGE's transmission line.

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category SOCIOECONOMICS

Potential Impact	Significance	Source
Adequacy of community services/ facilities due plant requirements, e.g., waste water, solid waste, police, fire.	Insignificant - Applicant will have to supply own water, provide for disposal of solid waste outside of venue of local government. Fire and police protection will be required only on rare occasions.	AFC, p. 5-90
<p>Adequacy of community services/ facilities due to increased population services/facilities demanded could include:</p> <ul style="list-style-type: none"> -Sewer -Water -Transportation -Police protection -Fire protection -Solid waste -General government -Schools -Medical care -Electrical and gas utilities -Parks and recreation -Flood control and drainage -Telephone and communications -Housing 	<p>Insignificant - Population increase is small relative to existent local population.</p> <p>Significant - Cumulative impacts are known significant for the Middletown Unified School District, and may be significant for other public services as well in Lake County.</p>	AFC, p. 5-89 to 5-93
Change in capitol requirements, operating costs and revenues of local service providers.	<p>Insignificant - Small population impact.</p> <p>Significant - Cumulative effect upon Middletown School District. Impacts may be mitigated due to AB 1905 monies.</p>	AFC, p. 5-92 and 5-93

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category - Socioeconomics

Potential Impact	Significance	Source
Adequacy of local transportation systems to accommodate construction and operation.	<u>Significant</u> : Lake County roads are deemed inadequate to handle substantially increased traffic. Roads are to be improved for the SMUDGE0 project. Impacts may be mitigated due to added tax revenue.	AFC, P. 5-91 to 5-93
Potential depletion of municipal water supplies by heat dissipating system.	<u>Insignificant</u> : No municipal water sources will be used.	AFC, p. 1-33
312 Potential degradation of the domestic water supply of the community of Anderson Springs by the complete development.	<u>Singificant</u> : If degradation of the community water system occurs due to the full Oxy development, it could have a significant financial impact on the Anderson Springs Water Co. and on the users; however, such degradation has yet to be demonstrated. See Water Quality Section of EIR.	

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category	Land Use	
Potential Impact	Significance	Source
<p><u>POWER PLANT</u></p> <p>Consumption of land for generating plant and related facilities.</p> <p>Compatibility with nearby existing and planned land uses, and/or land use designations including General Plan.</p>	<p><u>Insignificant</u> - Land use designation allows for energy facilities.</p> <p>Compatible. Extensive agriculture designation allows for development of geothermal power plants.</p>	<p>AFC, p. 5-83</p> <p>AFC, p. 5-83</p>
<p>313 <u>WELL FIELD</u></p> <p>Change in land use due to exploration and extraction.</p> <p>Change in land use required for fill disposal.</p> <p>Compatibility with nearby existing and planned land use (including General Plan) and/or land use designations.</p>	<p><u>Insignificant</u> - Consistent with present uses.</p> <p><u>Insignificant</u> - All fill material will be utilized on the project leasehold.</p> <p>Compatible. Extensive agriculture designation is compatible with geothermal energy development.</p>	<p>AFC, p. 5-83</p> <p>AFC, p. 1-10</p> <p>AFC, p. 5-83</p>
<p><u>TRANSMISSION LINES</u></p> <p>Utilization of land for electric transmission.</p> <p>Compatibility of transmission lines with adjacent land use.</p>	<p><u>Insignificant</u> - Corridor is short and within geothermal development.</p> <p>Compatible - Extensive agriculture designation is compatible with geothermal energy development.</p>	<p>AFC, p. 8-5</p> <p>AFC, p. 8-5</p>

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category

Aesthetics

Potential Impact

Significance

Source

POWER PLANT

Alteration or disruption of aesthetics attributes of viewscape and/or site due to construction of power plant and related facilities.

Insignificant - Views of power plant are limited to just a few areas which include Mt. St. Helena. However, these views include not only the proposed power plant site but also other geothermal developments.

AFC, p. 5-95-97

Aesthetic impacts upon nearby residents:

Insignificant - Nearby residents who are located no closer than two miles from the site, will not be able to view the power plant because of topography and vegetation. See Environmental Categories:

AFC, p. 5-95-97

- Visual
- Noise
- Odors

- Noise
- Public Health
- Air Resources

WELL FIELD

Alteration or disruption of visual attributes of site by exploration and production of geothermal resource.

Insignificant - Direct aesthetic impacts related to drilling activities will be experienced only at times during facility construction, and for only short periods of time, however, see Water Quality Section of EIR for potentially significant impacts to Anderson and Gunning Creeks.

E.g. Ecoview, Final Impact Report for Geothermal Leasehold of the Union Oil Co. February 1975, p. 16-18

INITIAL ENVIRONMENTAL IMPACT EVALUATION

Environmental Category	Aesthetics	
Potential Impact	Significance	Source
<u>TRANSMISSION LINES</u> Accessibility to new vantage points allowing people easier access to areas, thereby effecting aesthetic attributes. Alteration or disruption of aesthetic attributes of viewscape and/or route for transmission system.	<u>Insignificant</u> - No new access will be promoted by preferred transmission route. <u>Insignificant</u> - New lines on the preferred route will be minimally visible outside of the KGRA in certain communities to the east.	AFC, p. 8-5 AFC, p. 8-5

APPENDIX B-1

POTENTIAL HEALTH EFFECTS OF GEOTHERMAL POLLUTANTS

AIR POLLUTANTS

Geothermal steam contains contaminants which, when inhaled or ingested in sufficient quantities, can adversely impact human health. These include regulated pollutants, such as hydrogen sulfide (H_2S), radon-222, and particulate matter, and nonregulated pollutants such as ammonia, mercury, arsenic, and boron. Abatement systems also emit varying amounts of pollutants such as vanadium, anthraquinone disulfonic acid (ADA), hydrogen peroxide, iron, sodium carbonate, sodium sulfate, and sodium thiosulfate. Some of these pollutants can react in the ambient air to form secondary pollutants such as sulfur dioxide and sulfates.

The potential for adverse impacts to public health depends on (1) the toxicity of the emitted contaminants, (2) the concentration or quantity to which the public is exposed by inhalation of polluted air or ingestion of contaminated drinking water or food, and (3) the duration of that exposure. The following discussion addresses potential adverse human health impacts associated with these contaminants.

REGULATED POLLUTANTS

Hydrogen Sulfide (H_2S)

Hydrogen sulfide is a toxic gas which can be fatal to humans when inhaled in concentrations of 1,000 ppm and above for several minutes (NIOSH, 1977). Longer exposure to lower concentrations can also be fatal. In concentrations above the state occupational standard of 10 ppm (8-hour average), H_2S causes eye and respiratory tract irritation, lung damage, and unconsciousness. Hydrogen sulfide levels below 10 ppm may induce decreased corneal reflex, nausea, insomnia, headaches, loss of sleep, and other symptoms (Walton and Simmons, 1978). The effects of exposure to various concentrations are summarized in Table B-1.

Relatively few studies examine adverse health effects from exposure to H_2S at low concentrations (less than 0.1 ppm) such as those measured in populated areas around The Geysers KGRA. The small number of relevant studies and questions concerning the validity of results from some of these studies leads to controversy regarding the potential for adverse effects from H_2S at low concentrations.

Some experts do not believe that exposure to concentrations below one ppm adversely affects human health (Simmons, 1979). The State of Montana recommends an H_2S standard of 0.05 ppm based on reported health effects (MAQB, 1980). The Canadian Ambient Air Quality objectives include a proposed maximum desirable level for H_2S of 0.66 ppb (1-hour average), and proposed maximum acceptable levels of 3.6 ppb (24-hour average), and 10.8 ppb (1-hour average) (Katz, 1980). The lowest concentration accepted by other experts as inducing adverse health effects is 0.08 ppm (IIEQ, 1974), almost 3 times greater than the California ambient air quality standard for H_2S ; chronic exposure to

TABLE B-1

HUMAN HEALTH EFFECTS OF HYDROGEN SULFIDE

ppm*	Health Effects	Reference
0.00047- 0.0045	Odor threshold	Leonardos, 1969 Wilby, 1969
0.007- 0.03	Slight odor	Gurinov, 1952
0.03	California ambient air quality standard for one-hour average (concentration based on the odor threshold)	ARB, 1970
0.04- 0.13	Clear definite odor	Gurinov, 1952
0.08	Increased incidence of mental depression, dizziness and blurred vision	IIEQ, 1974
0.30	Increased incidence of nausea, insomnia, shortness of breath and headaches with chronic exposure	Indiana APCD, 196
0.7-7	Incidence of decreased corneal reflex with chronic exposure	IIEQ, 1974 Rubin, 1975
4.6	Readily apparent, offensive odor	Simson, 1971 Yant, 1930
10	Threshold limit value for 8-hour exposure at the work place	ACGIH, 1977
10- 50	Threshold for irritative action with prolonged exposure: eye irritation such as conjunctivitis and at the higher concentrations dry throat. Fatigue, loss of appetite and insomnia with chronic exposure	Ahlborg, 1951 Gurinov, 1952 NIH, 1941
20- 30	Very strong, but not intolerable odor	IIEQ, 1974 Yant, 1930
70- 150	Eye irritation after several hours of exposure; conjunctivitis, keratitis and photophobia. Threshold for olfactory paralysis occurring within minutes	Devege, 1956 Evans, 1967 Mitchell, 1925 AIHA, 1963
200- 300	Serious local irritation to eyes and respiratory tract caused upon inhalation for one hour, with possible subsequent pulmonary edema. This is the maximum concentration which can be inhaled for one hour without serious consequences.	Mitchell, 1925 Haggard, 1925

Adapted from Walton and Simmons, 1978

this concentration may cause nausea, fatigue, loss of appetite, dizziness, blurred vision, and increased incidence of mental depression.

Some studies report adverse health effects at exposure levels below 0.08 ppm; the validity of these low level studies, however, is questionable (Weres, 1977; Walton and Simmons, 1978). Nevertheless, the possibility that these low levels can induce adverse health effects calls for further investigation.

Exposure to H_2S may be more harmful to certain groups of individuals than to the general population. These H_2S sensitive groups include infants; individuals with anemia, eye or respiratory problems, and schizoid or paranoid tendencies; and those who have recently consumed alcohol (IIEQ, 1974; Walton and Simmons, 1978).

Hydrogen sulfide's characteristic rotten egg odor can be detected at low concentrations. The odor detection threshold, varying with individual sensitivity, has been reported as high as 0.14 ppm and as low as 0.00047 ppm (Walton and Simmons, 1978). Different experimental techniques, subject training, and difficulties in accurately preparing very dilute hydrogen sulfide concentrations may contribute to the wide discrepancy between reported thresholds. At high concentrations (70 - 150 ppm) hydrogen sulfide causes olfactory paralysis--loss of sense of smell (Weres, 1977; Walton and Simmons, 1978).

The California State Ambient Air Quality Standard for H_2S is 0.03 ppm (1-hour average). Although public health protection was considered, this value was based on the average H_2S odor threshold obtained in a study conducted by the California Department of Public Health (CARB, 1970). In that study H_2S odor thresholds for 16 individuals ranged from 0.012 to 0.069 ppm; the average was 0.029 ppm H_2S . In a report prepared by Lawrence Berkeley Laboratories, Case (1977) states that if the standard is to be based on known odor threshold, "...then the standard should be lowered by a factor of 3 to 5 to the more recently accepted value for the odor perception threshold."

Radon-222

The primary health hazard associated with radon-222 and its short-lived daughter products is inhalation and possible deposition in the lung. Radon-222 itself is usually inhaled and exhaled without deposition on lung tissue. However, the short-lived daughter products of radon-222 (especially those which emit alpha particles) have a high probability for deposition. Deposition of an alpha-emitting substance on the lungs provides a greater potential for temporary or permanent tissue damage from the natural destructive action of the alpha energy.

NONREGULATED POLLUTANTS

Geothermal steam also contains pollutants for which there are no federal or California ambient air quality standards, including mercury, arsenic, benzene, silica, boron, and ammonia. Abatement systems emit ADA, vanadium, hydrogen peroxide, iron, sodium carbonate, and sodium thiosulfate. These substances could cause adverse health impacts if present in sufficient concentrations. Suggested standards and safe levels for these pollutants in air are listed in Table 4, Public Health Impacts.

Ammonia

Ammonia is primarily an eye, mucous membrane, and upper respiratory tract irritant. The lowest reported concentration causing irritation in humans via inhalation is 20 ppm (EPA, 1977). Barely noticeable eye irritation may occur at five ppm (NIOSH, 1974). EPA believes that exposure to low levels of ammonia does not cause permanent adverse health effects (EPA, 1977). The odor threshold for ammonia ranges between approximately 0.7 ppm and 50 ppm (NAS, 1977). A recent study (Larson et al., 1978) reported mean concentrations of ammonia in human breath of 157 ug/m³ (0.23 ppm).

Mercury

Inhalation of mercury compounds can induce cough, fever, bronchitis and pulmonary edema. Accumulation of mercury in the brain, kidneys, and hair causes chronic poisoning with symptoms such as headaches, dizziness, and fever. Children are especially susceptible to mercury poisoning (Britt and Hushon, 1976). Certain mercury compounds may cause cancer or birth defects (EPA, 1977).

Arsenic

Geothermal steam contains arsenic and arsenic compounds in varying forms, such as suspended particulates or vapors. Depending on concentration and form, acute exposure to arsenic may cause headaches, dizziness, numbness, chills and fever, nausea, vomiting, abdominal pain, pulmonary edema, jaundice, and leukocytosis. Chronic exposure may cause irritation to nose and throat, hair loss, tremors, anemia, and cancer of the skin, lung, or liver (Britt and Hushon, 1976).

Boron

Compared with information on other atmospheric pollutants, the medical literature on boron and its compounds is sparse (Waldbott, 1973). Boron and most boron compounds are not highly toxic (Waldbott, 1973; Durocher, 1969), although boron hydrides are rated as highly toxic (Durocher, 1969). Chronic exposure to boron and boron compounds can result in reduced appetite, nausea, weight loss, increased risk of lung infection, central nervous system depression, and kidney injury (Britt and Hushon, 1976). Inhalation of boric acid and boron oxide in the form of dust can cause respiratory irritation but is not likely to induce permanent damage (Waldbott, 1973). Inhaling boron hydrides (boranes) can result in severe central nervous system damage with symptoms including headache, dizziness, drowsiness, convulsions, fever, cough and pneumonia (Wilcox, 1973; Waldbott, 1973); such exposure may also cause death or permanent damage (Durocher, 1969).

Vanadium

Acute exposure to excessive concentrations of vanadium can cause conjunctivitis, skin irritation, chest pain, cough, asthma, pneumonia, nausea and vomiting, headache, and tremor. Effects include hypertension, cardiovascular disease, kidney damage, anemia, emphysema, and pulmonary fibrosis (Britt and Hushon, 1976). Studies suggest that vanadium may be an essential element for some animals, including man, at low concentrations (WHO, 1973).

Anthraquinone Disulfonic Acid (ADA)

Stretford solution contains anthraquinone 2:7 disulfonic acid (PGandE, 1979b), an aromatic compound most commonly used in the dye industry (Stern, 1977). Few sources describe health effects from exposure to ADA. Anthraquinone is a naturally occurring mutagenic compound (Ames, 1979). It has low systemic toxicity to humans, but may cause skin irritation sensitization (The Merck Index, 1968). Anthraquinone 1:5 disulfonic acid and anthraquinone 1:8 disulfonic acid are suspected to have low toxicity (The Condensed Chemical Dictionary, 1972).

Hydrogen Peroxide

Exposure to hydrogen peroxide fumes represents an occupational health concern rather than a public health concern. Hydrogen peroxide is nonflammable but, since it is an oxidizing agent, it helps to support combustion. Hydrogen peroxide, by itself, is not as toxic as when it is in combination with other pollutants such as ozone. Svirbely et al. (1961) reported ozone (1 ppm) combined with hydrogen peroxide at concentrations above 1.5 ppm was lethal to some animals, whereas hydrogen peroxide by itself, in a concentration of 200 ppm, produced only slightly toxic responses.

Iron

Fine iron oxide particulates at high concentrations may cause conjunctivitis, chronic bronchitis, pulmonary fibrosis, and emphysema. Iron oxide can penetrate the walls of the lung bronchi and alveoli without damage to the mucous or ciliary barrier. In this way it can transport other compounds into the lungs (Waldbott, 1973). Ingesting very high concentrations of ferric sulfate causes vomiting, tachycardia, liver insufficiency, and capillary damage.

Sulfates

High sulfate concentrations are associated with increased asthmatic attack frequency, worsened symptoms in cardiopulmonary patients, decreased ventilatory function in school children, and symptoms of acute and chronic diseases in children and adults (Bachman, 1975).

Benzene

Chronic benzene exposure may result in poisoning characterized by blood disorders (leukemia), changes in body organs, chromosomal aberrations, and cancer; acute exposure to benzene has a narcotic effect (EPA, 1977). Benzene can be absorbed through the skin, but inhalation is the usual mode of exposure.

Silica

High silica concentrations, especially crystalline free silica, can cause silicosis, a serious disabling lung disease also affecting the heart.

Asbestos

Inhalation of asbestos particles can cause asbestosis, scarring of the lungs similar to other "dust lung" diseases. Early symptoms, cough and breathlessness on exertion, are often not manifest for 20 to 30 years after the first exposure to asbestosis. Advanced stage symptoms include bluish skin discoloration and restricted chest expansion (Waldbott, 1973).

Prolonged inhalation of asbestos can cause lung cancer, particularly in smokers. Experimental asbestos exposure has produced cancers of the intestine and pulmonary airways (Sax, 1979; Waldbott, 1973).

APPENDIX B-2

POTENTIAL HEALTH EFFECTS OF GEOTHERMAL POLLUTANTS

WATER POLLUTANTS

Geothermal development may degrade drinking water quality due to soil erosion, trucking accidents, petroleum product and other chemical spills, pipeline breaks, and well pad sump failures. The potential for adverse public health impacts depends on (1) the toxicity of the contaminants, (2) the concentration or quantity of contaminants to which the public is exposed, (3) the duration of exposure, and (4) the contaminant removal ability of local water treatment facilities. The following discussion addresses potential adverse human health impacts associated with water pollutants.

Suspended and Settleable Solids and Turbidity

Suspended and settleable solids include materials such as clay, sand, finely divided organic matter, bacteria, and plankton (Britt and Hushon, 1976). Suspended clay particles may absorb toxic chemicals, including metals, radioactive materials, and pesticides, that may be in the water (Britt and Hushon, 1976). Suspended matter also provides surfaces where microorganisms are protected from chlorination, resulting in either higher chlorine demand or, if chlorine levels are not adjusted, greater numbers of viable microorganisms in drinking water. If consumed, toxic chemicals and microorganisms in drinking water can adversely affect human health (see following sections on these contaminants).

The federal standard is one turbidity unit* (as determined by a monthly average) at the point of entry into the drinking water distribution system (EPA, 1976). Bean (1961) has proposed that for drinking water of ideal quality, suspended matter concentrations be limited to 0.1 mg/l or less.

Bacteria

Coliform bacteria serve as primary indicators of contamination with fecal matter from humans and warm-blooded animals (EPA, 1976). Ordinarily coliforms are harmless, though some strains may cause diseases in humans (McKee and Wolf, 1963). Growth of some coliform bacteria can impart tastes and odors to water due to their own metabolic waste products or by transformation of proteins, sulfates, or other chemicals present in water (McKee and Wolf, 1963).

Bacterial diseases that have been transmitted by contaminated water include intestinal illnesses, such as dysentery and gastroenteritis, and less frequently, tuberculosis and other diseases (McKee and Wolf, 1963).

The transmission of disease by bathing waters has not been established epidemiologically as a major public health hazard (McKee and Wolf, 1963; EPA, 1976). Water containing an average of 0 to 50 coliform/ 100 ml is considered to be good quality for recreational use (McKee and Wolf, 1963).

*Measurement of turbidity is based upon a comparison of the amount of light passing through the given water sample with that passing through a standard sample (McKee and Wolf 1963).

Petroleum Products

The potentially deleterious effects of oily substances upon domestic water supplies include (a) health hazards to consumers, (b) foul tastes and odors, (c) turbidity, films, or iridescence, and (d) difficulty of water treatment (McKee and Wolf, 1963).

Petroleum derivatives cause objectionable tastes and smells at concentrations far below human chronic toxicity levels. Therefore, drinking oil-polluted waters is unlikely to cause health hazards because such water supplies would be unfit for human consumption (EPA, 1976; McKee and Wolf, 1963).

H₂S Abatement System Chemicals and Wastes

- o Anthraquinone Disulfonic Acid (ADA)--Very little information is available which describes health effects from exposure to ADA. Toxic effects to animals injected with anthraquinone have been reported (Patty, 1963). Anthraquinone may be toxic to humans, but studies indicate that it is not carcinogenic (Santodonato, 1979).
- o Vanasol--Vanasol is a vanadium compound. Vanadium may be an essential element for mammals (Britt and Hushon, 1976), and in low concentrations reduces the incidence of dental caries in both primary and permanent teeth (McKee and Wolf, 1976). Vanadium is absorbed through the lungs and to a slight extent through the intestine, although it is largely unabsorbed and rapidly excreted (Britt and Hushon, 1976). Vanadium inhibits synthesis of cholesterol and accelerates its catabolism. Long-range effects of vanadium exposure include hypertension, cardiovascular disease, kidney damage, anemia, emphysema, and pulmonary fibrosis (Britt and Hushon, 1976). High concentrations can inhibit growth and cause death (McKee and Wolf, 1963). There is no evidence that vanadium is teratogenic, carcinogenic, or mutagenic (Britt and Hushon, 1976).
- o Stretford Unit Sulfur Cake and Sulfur Compounds--Elemental sulfur is insoluble in water but may be present in suspension in colloidal state (McKee and Wolf, 1963). Sulfates occur naturally in water as a result of leachings from gypsum and other common minerals. The federal drinking water standard of 250 mg/l sulfates is based on a laxative action toward new users (McKee and Wolf, 1963). The state water quality criterion is 500 mg/l for domestic water supply (McKee and Wolf, 1963).

The federal water quality criterion for sulfides is 2 ug/l undissociated H₂S, based on protection of fish and other aquatic life, not human health. Due to the unpleasant odor and taste of sulfides in water, it is unlikely that people will drink a harmful dose (McKee and Wolf, 1963).

- o Hydrogen Peroxide--Hydrogen peroxide is a strong oxidizing agent and supports combustion, especially in the presence of metallic compounds acting as catalysts (CEC, 1980). Hydrogen peroxide can irritate skin, eyes, and mucous membranes via oral and inhalation routes (Sax, 1979).
- o Iron--At The Geysers, iron catalysts are used in H₂S abatement processes. Humans require a daily iron intake of 1 to 2 milligrams. The state and federal water quality criterion of 0.3 mg/l iron in domestic water

supplies is based on prevention of objectionable tastes and laundry staining and is an aesthetic rather than toxicological criterion (EPA, 1976). The taste threshold varies for iron compounds, ranging from 0.04 mg/l for ferrous sulfate to 1.8 - 10 mg/l for ferric sulfate (McKee and Wolf, 1963).

Drilling Wastes

Drilling wastes are a combination of drilling mud and rock cuttings. Drilling mud is predominantly composed of water and bentonite clay with various minor additives including tannins, lignin, chromium compounds, caustic soda, and sodium phosphate compounds (Gennis and Associates, Engineers, 1977).

- o Tannic Acid--Tannic acid occurs naturally in tree bark. It is highly soluble in water and has a high chlorine demand. Tannic acid gives water a woody taste and odor in concentrations of 2.0 to 4.0 mg/l (McKee and Wolf, 1963).
- o Lignin--Lignin is the noncellulosic portion of wood which holds the cellulose fiber together (Hampel and Hawley, 1976). Available data do not indicate that lignin is toxic to humans.
- o Chromium Compounds--Chromium is an essential trace element for humans; however, excessive levels can be toxic. Hexavalent chromium, generally considered to be the more hazardous form (EPA, 1977), can irritate and corrode mucous membranes when inhaled or ingested. Other health effects include dermatitis, ulceration, gastritis, stomach ulcers, and colitis (Britt and Hushon, 1976). The state water quality criterion is 0.050 mg/l for domestic water supply based on protection of human health. The California Department of Health Services lists some chromium compounds as hazardous wastes due in part to toxic and irritant properties (DHS, 1979). The federal criteria are 0.05 mg/l for hexavalent chromium and 170 mg/l for trivalent chromium (EPA, 1980).

Geothermal Steam Condensate and Cooling Tower Sludge

CEC staff does not have complete data on cooling tower sludge constituents but expects the sludge to contain the following geothermal steam constituents and radionuclides.

- o Hydrogen Sulfide--See comments on sulfides under Stretford Unit Sulfur Cake.
- o Ammonia--Although ingestion of very high concentrations of ammonia (28 - 29 percent) in water can be fatal, there appears to be no physiological harm to humans in concentrations of ammonia that might occur in natural or polluted waters (McKee and Wolf, 1963). The federal criterion is 0.02 mg/l (as un-ionized ammonia) for protection of freshwater aquatic life (EPA, 1976).
- o Arsenic--Arsenic in drinking water is toxic and may be carcinogenic (EPA, 1976; McKee and Wolf, 1963). Both acute exposures to high concentrations and chronic exposures to low concentrations can be fatal (McKee and Wolf,

1963). Symptoms of mild chronic arsenic poisoning are fatigue and loss of energy; severe intoxication is characterized by kidney degeneration, liver cirrhosis, bone marrow injury, and other symptoms (EPA, 1976). The state criterion is 0.05 mg/l arsenic in domestic water supplies based on protection of human health. The federal criterion states that "for the maximum protection of human health from the potential carcinogenic effects due to exposure of arsenic through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical" (EPA, 1980). EPA estimates an incremental increase of cancer risk over the lifetime of 1 in 100,000, 1 in 1,000,000, and 1 in 10,000,000 if arsenic concentrations in water are 0.022 ug/l, 0.0022ug/l or 0.00022 ug/l, respectively (EPA, 1980).

- o Boron--Boron in drinking water is generally not regarded as a hazard to human beings. In very high concentrations it may interfere with digestion due to its preservative action on foods (McKee and Wolf, 1963). The federal criterion is 0.750 mg/l boron in irrigation water for sensitive crops; no criterion exists for human health (EPA, 1976).
- o Mercury--Mercury and its salts are considered to be highly toxic to humans (McKee and Wolf, 1963). Mercury intoxication may be acute or chronic, the latter resulting from exposure to small amounts over extended time periods. Since mercury bioaccumulates, consuming fish from mercury-contaminated waters can cause mercury poisoning in man. The federal criterion is 0.144 ug/l mercury to protect human health.
- o Radionuclides--Chronic effects arising from frequent small doses of radiation are difficult to evaluate. Production of eye cataracts, induction of leukemia from irradiation of the bone marrow, development of bone cancer from ingestion of radium, production of skin cancer, and reduction of life span by imperceptible impairment of many bodily functions may result (McKee and Wolf, 1963). Experts do not agree on threshold levels for exposure to radioactivity giving rise to these effects.

The U.S. Environmental Protection Agency has promulgated the following maximum contaminant levels for radiation in drinking water based on health effects and control costs: 5 picocuries per liter of radium-226; 15 pCi/l gross alpha particle activity (excluding radon and uranium); less than 4 millirems per year to total body or any organ of manmade beta particle and photon emitters (Britt and Hushon, 1976).

Based on PGandE estimates of radionuclide content in Geysers Unit 18 sludge (Table B-2), contamination of creeks with cooling tower sludge would have a similar impact on radionuclide levels as contamination with an equal amount of soil.

- o Silica--Silica, or silicon dioxide, is insoluble in water, but it may occur as suspended matter. In concentrations found in natural or treated waters, silica or silicates appear to cause no adverse physiological effects. At 50 mg/l or greater concentrations silica may cause turbidity problems (McKee and Wolf, 1963).

Table B-2

ESTIMATED RADIONUCLIDE CONTENT IN GEYSERS UNIT 18 SLUDGE

<u>Radionuclide</u>	<u>Sludge Concentration pCi/g</u>	<u>Soil¹ Concentration Range pCi/g</u>	<u>Reference Standard² Concentration pCi/g</u>
238 _U	0.4	.08 - 3.0	40
232 _{TH}	0.1	.028 - 4.3	40
226 _{Ra}	0.7	.074 - 3.0	30
210 _{Pb}	9.0	.14 - 830 ³	200
40 _K	5.0	0.2 - 39	NA
Fallout and cosmogenic	2.0 ⁴	-	40 ⁴

1. Reference data and Geysers measurements.

2. California Administrative Code, Code of Federal Regulations.

3. Measurements of 210_{Pb} in a atmospheric particulates.

4. Typical values.

Source: CEC, 1980.

- o Benzene--Benzene poisoning occurs most commonly through inhalation of the vapor (Sax, 1979). Chronic benzene exposure may result in poisoning characterized by blood disorders (leukemia), changes in body organs, and chromosomal aberrations (EPA, 1977). Benzene is listed in the NIOSH Suspected Carcinogens List. For the maximum protection of human health from the potential carcinogenic effects of benzene, the federal criterion states the ambient water concentration should be zero based on the assumption that there is no threshold for carcinogenic effects (EPA, 1980). EPA estimates an incremental increase of cancer risk over the lifetime of 1 in 100,000 at 6.6 ug benzene/liter, 1 in 1,000,000 at 0.66 ug/l, and 1 in 10,000,000 at 0.066 ug/l (EPA, 1980).
- o Asbestos--Asbestos exposure through ingestion of contaminated water and contaminated aquatic organisms may cause cancer in the human digestive tract. Currently available data, however, does not provide adequate information to assess this potential health hazard (Spath, 1981; Seversen, 1979). The federal government is presently funding several studies designed to help determine the significance of asbestos exposure by ingestion (Millette, 1981).

The federal criterion states that for the maximum protection of human health from the potential carcinogenic effects, the ambient water concentration should be zero based on the assumption that there is no threshold for the effects of this chemical (EPA, 1980). EPA estimates an incremental increase of cancer risk over the lifetime of 1 cancer per 100,000 people at 300,000 asbestos fibers/liter, 1 cancer per 1,000,000 people at 30,000 fibers/liter, and 2 cancer per 10,000,000 people at 3,000 fibers/liter (EPA, 1980).

Contaminants in water in The Geysers KGRA occasionally found in excess of standards (see Water Quality Setting section):

- o Turbidity--See discussion of suspended and settleable solids and turbidity above.
- o Iron--See iron catalysts above.
- o Manganese--Manganese is an essential element; daily intake in a normal human diet is about 10 mg. However, high concentrations in drinking water have caused chronic manganism, a disease of the central nervous system; initial symptoms include failure of strength, apathy, nervousness, headaches, and pains in lower extremities (Britt and Hushon, 1976). McKee and Wolf (1963) believe manganese cannot be considered a physiological hazard because toxic levels would not be tolerated aesthetically in drinking water. Manganese causes unpleasant tastes at 0.5 to 180 mg/m³, deposits on food during cooking, stains and discolors laundry and plumbing fixtures, and fosters microorganism growth (McKee and Wolf, 1963). Furthermore, low iron concentrations may intensify the adverse effects of manganese (EPA, 1976). The state criterion is 0.05 mg/l manganese for domestic water supply (McKee and Wolf, 1963).
- o Sulfate--See Stretford Unit Sulfur Cake above.

References for Appendix B-2

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APPENDIX C

ASSUMPTIONS FOR PUBLIC HEALTH IMPACT ANALYSIS

The following assumptions were used by CEC staff in the Public Health Impacts section.

1. Concentrations of pollutants in incoming steam were based on:
 - a. Utilities estimates where available;
 - b. Exploratory well data, where available; or
 - c. Average concentrations from 61 producing wells at The Geysers.
2. The total quantity of steam contaminants is released to the atmosphere through the cooling tower.

Note: This is an overestimation. In reality, some portion of incoming steam contaminants is reinjected with excess condensate or accumulates in sludge. The percentage that exits through the cooling tower varies depending on the volatility of the pollutant. This assumption allows for a worst-case analysis only; it is not precise.

3. The analysis assumes that all geothermal pollutants are transported in the atmosphere in the same manner as gaseous H_2S . This may not be entirely accurate, since some pollutants are likely to behave more like a particulate than a gas. Gaseous pollutants are generally more extensively dispersed than particulate pollutants.
4. The analysis for nonregulated pollutants is based on the cumulative impact study for H_2S . A similar set of assumptions used in the H_2S analysis applies:
 - a. Background pollutant levels assumed for nonregulated pollutants are lacking or outdated and may not apply in 1984 when the facility is scheduled for commercial operation.
 - b. It assumes that all nonregulated pollutants are emitted during normal operation and steam stacking, so there would be no increase during steam stacking or reduced H_2S abatement efficiency.
5. As meteorological conditions, this cumulative impact analysis assumes those conditions which result in the maximum impact of the project emissions on ambient pollutant concentrations in Anderson Springs (the nearest population center). These meteorological conditions do not necessarily cause the maximum impact from other units' emissions in this area. In addition, this analysis does not identify the maximum possible impact of these other units on Anderson Springs. Rather, it identifies the impact on pollutant concentrations in Anderson Springs when the project emissions have a maximum impact, given:

- a. All incoming pollutants are emitted through cooling towers and dispersed in the same manner as H₂S, and
 - b. Only limited emission and background and concentrations data are available.
6. Most available air quality data for The Geysers KGRA are expressed in terms of maximum hourly average pollutant concentrations. In order to make comparisons with suggested safe annual average concentrations, CEC staff assumes, as a worst case, that annual average pollutant concentrations are one-tenth the maximum hourly averages. Staff bases this assumption on historical H₂S data for The Geysers KGRA (Ruff et al., 1978). This value compares favorably to the value of roughly 0.1 predicted by a model used to compare pollutant concentrations in urban settings at various averaging times (Larsen, 1971) and to the worst case value of 0.09 ± 0.02 calculated by Tesche et al. (1980) from historical data for The Geysers KGRA. CEC staff assumes that the relationship between maximum hourly average and annual average concentrations is similar for geothermal pollutants other than H₂S.
7. Health Table 3 lists values for assessing potential public health impacts from nonregulated pollutants in ambient air. The following paragraphs describe the types of values in that table.
- o Threshold Limit Values (TLV^R), adopted by the American Conference of Governmental Industrial Hygienists, "...refer to airborne concentrations of substances to which nearly all workers may be exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from such substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness....Threshold limits are based on the available information from industrial experience, experimental human and animal studies, and, when possible, from a combination of these. The basis for established values may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may form the basis for others" (ACGIH, 1979). As previously noted, safe levels for generally healthy workers exposed for limited duration under controlled conditions may not represent safe levels for continual exposure of the general public, which can include pollutant sensitive individuals.
 - o The publication Multimedia Environmental Goals for Environmental Assessment (EPA, 1977) lists "levels of significant contaminants... in ambient air...that are judged to be appropriate for preventing certain negative effects in surrounding populations." The Multimedia Environmental Goals (MEGs) were developed as a first effort at establishing "a procedural approach to evaluate and rank a large number of pollutants for the purpose of environmental assessment." Such assessments can be used to determine further research needs and to set pollution control strategy development priorities.

Estimated permissible concentrations for the MEGs were derived using TLV^{Rs} or recommendations of the National Institute for Occupational Safety and Health (NIOSH), adjusting the values for continual exposure and incorporating a margin of safety. For some pollutants two values are listed: one based on toxicity, the other based on carcinogenic potential. Estimated permissible concentrations based on carcinogenic potential indicate estimated acceptable risk levels rather than established safe concentrations, since threshold levels for carcinogenic effects may not exist (EPA, 1977).

The MEGs receive criticism for their rather simple derivation and other inherent limitations or inconsistencies (such as the differing end points used in setting the TLV^{Rs} upon which the MEGs are based). CEC staff is currently following efforts by EPA to refine the MEGs.

- o The Wilcox (1973) study was part of a program with the EPA "to provide the analysis necessary to form a basis for planning and developing hazardous pollution control technology." The presumed safe ambient air quality levels reported by this study constitute estimates made by a panel of six experts. These experts in the fields of epidemiology, air pollution, and toxicology took experimental results, statistical data, and subjective philosophies of life into consideration to arrive at levels below which they would not expect any adverse health effects. Ideally, these proposed concentrations should be safe for the entire population to breathe daily. However, not all of the estimates for each pollutant are similar; not all of the experts have identical bases for their opinions. Health Table 3 lists the average of the six levels suggested by the experts.

SOILS APPENDIX D

TABLE 1	SOIL HYDROLOGIC INTERPRETATIONS
TABLE 2	SOIL MAP UNIT CHARACTERISTICS
TABLE 3	SOIL PRODUCTIVITY INTERPRETATIONS
TABLE 4	WILDLIFE HABITAT SUITABILITY
TABLE 5	SCHEDULE FOR IMPLEMENTING THE OXY MITIGATION PLAN
TABLE 6	MONITORING SCHEDULE

SCS WIND ERODIBILITY POTENTIAL OF BARE SOILS BY SOIL GROUPS

<u>Group</u>	<u>Soil Classes</u>	<u>Hazard</u>
1	Sands	High
2	Loamy Sands	High
3	Sandy Loams	Medium
4	Silty Clays & Clays	Medium
5	Loams, Sandy Clay	Slight
6	Silt Loams, Clay	Slight
7	Silty Clay Loams	Slight
8	Wet or Stony	Slight

Table 1
SOIL HYDROLOGIC INTERPRETATIONS

SCS Map Unit	Series	Hydro- logic Group ¹	Drainage Class ²	Erosion Hazard Rating	Depth (in.)	Texture (if determining)	Erosion Factors <u>K³</u> <u>T⁴</u>		Wind Erodibility Group ⁵	Organic Matter (%)	Perm. (in/hr)
145	Henneke	D	well	high	0-5	clay to clay loam	.24	1	8	2-7	0.2-0.6
					0-5	loam to clay loam	.25	1	8	2-7	0.6-2.0
					5-19	all	.24		0-1	0.2-0.6	
	Montara	D	well	high	0-13	stony loam	.28	1	8	1-3	0.2-0.6
					0-13	stony clay loam	.32	1	8	1-3	0.2-0.6
	166	Forward Variant	B	well	mod.	0-7	all	.20	3	8	1-3
7-60+						all	.28				0.6-2.0
Kidd		D	somewhat excessive	high	0-10	gravelly	.24	1	8	1-2	2.0-6.0
					0-10	nongravelly	.32	1	3&5	1-2	2.0-6.0
					10-14	all	.24			0-1	2.0-6.0
170		Kidd	D	somewhat excessive	mod.	0-10	gravelly	.24	1	8	1-2
	0-10					nongravelly	.32	1	3&5	1-2	2.0-6.0
	10-14					all	.24			0-1	2.0-6.0

Table 1 - Continued
SOIL HYDROLOGIC INTERPRETATIONS

SCS Map Unit	Series	Hydro- logic Group ¹	Drainage Class ²	Erosion Hazard Rating	Depth (in.)	Texture (if determining)	Erosion Factors <u>K³</u> <u>T⁴</u>		Wind Erodibility Group ⁵	Organic Matter (%)	Perm. (in/hr)
335	Forward	C	well	mod.	0-7	gravelly sandy loam	.20	2	8	2-4	2.0-6.0
					0-7	gravelly loam	.20	2	8	2-4	2.0-6.0
					7-15	all	.28			.5-1	2.0-6.0
					15-24	all	.24			0-1	2.0-6.0
	389 Harbin	B	well	mod.	0-60	all	.10	5	8	1-2	0.6-2.0
	Whispering	B	well	high	0-5	all	.24	2	8	1-2	0.6-2.0
					5-15	all	.17			.5-1	
					15-26	all	.10			0-1	
	534 Maymen	D	somewhat excessive	high	0-15	gravelly	.28	1	8	.5-2	0.6-2.0
					0-15	nongravelly	.32	1	5	.5-2	0.6-2.0
	Hopland	B	well	high	0-12	all	.32	2	8	1-2	0.6-2.0
					12-31	all	.28			0-0.5	0.6-2.0
	Woodin	B	somewhat excessive	high	0-6	gravelly	.24	2	8	2-4	2.0-6.0
					0-6	very gravelly	.20	2	8	2-4	2.0-6.0
					6-13	all	.20			.5-2	0.6-2.0
					13-22	all	.20			.5-2	0.6-2.0

Table 1 - Continued
SOIL HYDROLOGIC INTERPRETATIONS

SCS Map Unit	Series	Hydro- logic Group ¹	Drainage Class ²	Erosion Hazard Rating	Depth (in.)	Texture (if determining)	Erosion Factors		Wind Erodibility Group ⁵	Organic Matter (%)	Perm. (in/hr)
							<u>K³</u>	<u>T⁴</u>			
534S	Maymen	D	somewhat excessive	high	0-15	gravelly	.28	1	8	.5-2	0.6-2.0
					0-15	nongravelly	.32	1	5	.5-2	0.6-2.0
	Montara	D	well	high	0-13	stony loam	.28	1	8	1-3	0.2-0.6
					0-13	stony clay loam	.32	1	8	1-3	0.2-0.6
536V	Etsel	D	somewhat excessive	high	0-3	gravelly	.20	1	8	1-2	0.6-2.0
					0-3	very gravelly	.10	1	8	1-2	0.6-2.0
					3-7	all	.10			0-1	0.6-2.0
541	Maymen	D	somewhat excessive	very high	0-15	gravelly	.28	1	8	.5-2	0.6-2.0
					0-15	nongravelly	.32	1	5	.5-2	0.6-2.0
	Etsel	D	somewhat excessive	high	0-3	gravelly	.20	1	8	1-2	0.6-2.0
					0-3	very gravelly	.10	1	8	1-2	0.6-2.0
					3-7	all	.10			0-1	0.6-2.0

Notes for Table 1

Note 1: Hydrologic Group:

Group B soils have a moderate infiltration rate when thoroughly wetted. These soils have a moderate rate of water transmission and moderate runoff potential. They are moderately deep or deep, are moderately well drained or well drained, and are medium textured to moderately coarse textured.

Group C soils have a slow infiltration rate when thoroughly wetted. These soils have a slow rate of water transmission and high runoff potential. They have a layer that impedes downward movement of water, or they are moderately fine textured or fine textured and have a slow infiltration rate.

Group D soils have a very slow infiltration rate when thoroughly wetted. The rate of water transmission is very slow, and runoff potential is very high. In this group are (1) clay soils that have high shrink-swell potential, (2) soils that have a permanent high water table, or (3) soils that have a claypan or clay layer at or near the surface.

Note 2: Drainage:

Well-drained: Water is removed from the soil readily but not rapidly. Well-drained soils are commonly intermediate in texture, although soils of other textural classes may also be well drained. Well-drained soils are free of mottlings (except for fossil gley), and horizons may be brownish, yellowish, grayish, or reddish. They may be mottled deep in the C horizon or below depths of several feet. Well-drained soils commonly retain optimum amounts of moisture for plant growth after rains.

Somewhat Excessively Drained: Water is removed from the soil rapidly. Some of the soils are shallow over bedrock. Many of them have little horizon differentiation and are sandy and very porous. Somewhat excessively drained soils are free of mottling throughout the profile. Only a narrow range of cover crops can be grown on these soils, and productivity tends to be low without irrigation.

Note 3: Erosion Factor K:

Inherent erodibility value, used in Universal Soil Loss Equation.

Note 4: Erosion Factor T:

Tons per acre erosional losses that will be tolerated before significant loss of productivity.

Note 5: Wind Erodibility:

Interpreted by WESCO using the following SCS Wind Erodibility Groups:

TABLE 2
SOIL MAP UNIT CHARACTERISTICS

<u>Map Unit (Slope %)</u>	<u>Series (% map unit.)</u>	<u>Landform and Lithology</u>	<u>Vegetation</u>	<u>Surface</u>	<u>Subsoil</u>
145 (15-30)	Henneke (40)	mountain sideslopes on serpentine & similar basic rocks	brush, scattered knobcone or digger pine	brown w/texture ranging from gravelly loam or clay loam to very gravelly clay loam or clay	reddish gray, very gravelly clay, or clay loam
	Montara (30)			gray stony loam to stony clay loam	--
	Rock outcrop (15)		barren		
	Inclusions (15)		brush		
	a) similar but deeper soils				
	b) similar but cooler soils				
166 (30-50)	Forward Variant (50)	steep mountain sideslopes on rhyolitic tuff & similar volcanic rocks	hardwoods & conifers w/ an understory of scattered brush & forbs	very pale brown very gravelly loam	very pale brown, very gravelly loam over light gray gravelly loam

TABLE 2 - Continued
SOIL MAP UNIT CHARACTERISTICS

Map Unit (Slope %)	Series (% map unit.)	Landform and Lithology	Vegetation	Surface	Subsoil
	Kidd (20)		brush & scattered conifers	light gray loam, sandy loam, gravelly loam or gravelly sandy loam	light gray gravelly loam to gravelly sandy loam
	Inclusions (30)				
	a) similar soils w/slopes 50%		woodland & brush		
	b) Cohasset		woodland	brown gravelly loam	light brown gravelly clay loam
	c) Rock outcrops		barren		
170 (5-30)	Kidd (60)	ridgetops on rhyolitic tuff & similar volcanic rocks	brush & scattered conifers	light gray loam, sandy loam, gravelly loam or gravelly sandy loam	light gray gravelly loam to gravelly sandy loam
	Forward (20)		conifers w/ an understory of shrubs	light gray gravelly loam to gravelly sandy loam	light gray sand loam & loam over gravelly sandy loam or loam
	Inclusions (20)				
	a) Cohasset		woodland	brown gravelly loam	light brown gravelly clay loam
	b) similar soils w/ clayey subsoils				
	c) Rock outcrops	escarpments	barren		

TABLE 2 - Continued
SOIL MAP UNIT CHARACTERISTICS

<u>Map Unit (Slope %)</u>	<u>Series (% map unit.)</u>	<u>Landform and Lithology</u>	<u>Vegetation</u>	<u>Surface</u>	<u>Subsoil</u>
389 (30-50)	Harbin (60)	stabilized land- slides on volcanic material, colluvial material on gray- wacke & shale	oaks & scattered conifers w/ an understory of shrubs	light brown very gravelly loam	light brown & reddish yellow very gravelly loam or clay loam
	Whispering (30)			brown loam	reddish yellow gravelly loam over red cobbly clay loam
	Inclusions (10) similar soils w/				
	a) slopes 30%				
	b) slopes 50%				
534 (30-50)	Maymen (40)	mountain side slopes on gray- wacke, sandstone and shale	brush	light yellowish brown sandy loam to a loam or gravelly sandy loam to gravelly loam	--
	Hopland (20)	north-facing & top slopes	dense brush & hardwoods	reddish brown loam	yellowish red clay loam or loam

TABLE 2 - Continued
SOIL MAP UNIT CHARACTERISTICS

<u>Map Unit</u> <u>(Slope %)</u>	<u>Series (% map unit.)</u>	<u>Landform</u> <u>and Lithology</u>	<u>Vegetation</u>	<u>Surface</u>	<u>Subsoil</u>
	Montara (20)			gray stony loam to stony clay loam	--
	Inclusions (20)				
	a) Rock outcrop				
	b) Hopland				
536V ² (50-80)	Rock outcrop (65)	mountain side- slopes on volcanics & sedimentary rocks	barren		
	Etsel (30)		brush & sparse annual grasses	light yellowish brown gravelly & very gravelly loam or sandy loam	--
	Inclusions (5)				
	a) Maymen				
	b) similar soils w/ slopes 50%				
541 (30-75)	Maymen (35)	mountain side- slopes on graywacke sandstone & shale	shrubs & sparse annual grasses	light yellowish brown sandy loam to a loam or gravelly sandy loam to gravelly loam	--

2. Volcanic variant of SCS map unit

TABLE 2 - Continued
SOIL MAP UNIT CHARACTERISTICS

<u>Map Unit</u> <u>(Slope %)</u>	<u>Series (% map unit.)</u>	<u>Landform</u> <u>and Lithology</u>	<u>Vegetation</u>	<u>Surface</u>	<u>Subsoil</u>
	Woodin (20)			very dark brown gravelly & very gravelly loam or sandy loam	very pale brown very gravelly & very cobble sandy loam, loam & sandy clay loam
	Inclusion (20)				
	a) Etsel & Bressa	south aspects ridgetops			
	b) Boomer & Speaker	north-facing ravines			
	c) Kroll	stabilized convex toe slopes			
	d) Henneke & Montara	serpentine intrusions	sparse brush		
	e) Rock outcrops				
534S ¹ (15-30)	Maymen (40)	mtn. sideslopes on sedimentary rocks influenced by & complexed w/ serpentine	brush w/ annual grasses	light yellowish brown sandy loam to a loam or gravelly sandy loam to gravelly loam	--

1. Shallow soils influenced by serpentine

TABLE 2 - Continued
SOIL MAP UNIT CHARACTERISTICS

<u>Map Unit</u> <u>(Slope %)</u>	<u>Series (% map unit.)</u>	<u>Landform</u> <u>and Lithology</u>	<u>Vegetation</u>	<u>Surface</u>	<u>Subsoil</u>
	Etsel (35)			light yellowish brown gravelly & very gravelly loam or sandy loam	--
	Inclusions (30)				
	a) Bressa & Millsholm	south-facing toe slopes			
	b) Hopland	north-facing slopes			
	c) Rock outcrops	upper sideslopes & ridgetops			

TABLE 3
SOIL PRODUCTIVITY INTERPRETATIONS

Map Unit	Series	Capability Unit ¹	Potential Productivity ² Normal Yr. (#/ac. dry wt.)	Fertility	Specific Concerns
145	Henneke	7E	600	very low	See footnotes 4a&b, 6 & 8.
	Montara	7S	900	low	See footnotes 6 & 8, 4a&b are applicable to most of the area.
166	Forward Variant	6E	400 ³	high	See footnotes 5, 7 is applicable under conifers.
	Kidd	7E	1,000 ³	moderate	See footnotes 4a&b, 5, & 6; 7 is applicable in some areas.
170	Kidd	6E	1,000 ³	moderate	See footnotes 4a&b, 5, & 6; 7 is applicable in some areas.
	Forward	3, 4E	500 ³	moderate	Footnote 7 in most areas.
389	Harbin	6E	1,000 ³	moderate	Footnotes 5 & 7 in a few areas.
	Whispering	6E	800 ³	moderate	Footnotes 5 & 7 in a few areas.
534	Maymen	7E	900	low	See footnotes 4a, 6, & 7; 5 is applicable north of Anderson Creek.
	Hopland	6E	1,200 ³	high	See footnote 6, 5 is applicable north of Anderson Creek.
	Woodin	6E	900 ³	moderate	See footnotes 6 & 7; 5 is applicable north of Anderson Creek.
534S	Maymen	7E	900	low	See footnotes 4a, 6 & 7; 5 is applicable north of Anderson Creek.
	Montara	7S	900	low	See footnotes 6 & 8, 4a&b are applicable to most of the area.
536V	Etsel	7E	1,800 (900 ³)	moderate	See footnotes 4a&b, 5 & 6; 7 is a concern in most places.
			344		

TABLE 3 - Continued

Map Unit	Series	Capability Unit ¹	Potential Productivity ² Normal Yr. (#/ac. dry wt.)	Fertility	Specific Concerns
541	Maymen	7E	900	low	See footnotes 4a, 6, & 7; 5 is applicable north of Anderson Creek.
	Etsel	7E	1,800 (900 ³)	moderate	See footnotes 4a&b, 5, & 6; 7 is a concern in most places.

FOOTNOTES TO TABLE 3

Capability units. Capability grouping was designed to show, in a general way, the suitability of soils for most kinds of common crops and, as such, is not a substitute for interpretation designed to show suitability and limitations of groups of soils for range, forest trees, or engineering. It is applicable in ranking the relative difficulty to be anticipated when using implements to prepare seedbeds. Definitions of the classes and subclasses follow.

Capability Classes, the broadest groups, are designated by numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class 1	Soils have few limitations that restrict their use.
Class 2	Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
Class 3	Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
Class 4	Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
Class 5	Soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.
Class 6	Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
Class 7	Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

FOOTNOTES CONTINUED

Class 8 Soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to aesthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, w, s, or c to the class numeral. The letter e shows that the main limitation is that of erosion unless close-growing plant cover is maintained; w shows that water is or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, saline, or stony; and c, used in only some parts of the United Statesm shows that the chief limitation is climate that is too cold or too dry.

²Productivity or potential native plant community of rangeland or forest understory vegetatiuon.

³Not currently available from SCS, estimated by WESCO.

⁴Available water holding capacity less than 2 inches due to a) shallow depth or b) high volume of coarse fragments.

⁵Southern aspects.

⁶High erosion hazard.

⁷pH less than 6.0

⁸Low Ca:Mg.

⁹Personal communication with Walt Cheechau, SCS, (10/9/80) indicated that this lower estimate better reflects conditions as described to him.

TABLE 4
WILDLIFE HABITAT SUITABILITY

Potential for Habitat Elements													
Series	Slope Phase	Grain and Seed	Grass and Legume	Wild Herb	Hard-wood Trees	Conifer Plants	Shrubs	Wet-land Plants	Shallow Water	Potential Habitat for Wildlife in:			
										Openland	Woodland	Wetland	Rangeland
Etsel	all	very poor	very poor	fair	very poor	very poor	fair	very poor	very poor	very poor	very poor	very poor	fair
Forward	all	poor	fair	fair	--	good	good	very poor	very poor	fair	good	very poor	fair
Forward Variant	all	--	--	poor	good	good	good	--	--	--	good	--	fair
Harbin	all	--	--	fair	good	good	good	--	--	poor	good	--	fair
Henneke	all	very poor	very poor	poor	--	--	poor	very poor	very poor	very poor	--	very poor	poor
Hopland	all	--	poor	poor	good	--	fair	--	--	--	fair	--	--
Kidd	5-30%	poor	fair	poor	poor	very poor	fair	very poor	very poor	poor	poor	very poor	poor
	30+%	very poor	very poor	poor	poor	very poor	fair	very poor	very poor	very poor	very poor	very poor	poor
Maymen	all	very poor	very poor	poor	--	--	good	very poor	very poor	fair	very poor	very poor	--
Montara	all	very poor	very poor	poor	--	--	fair	very poor	very poor	very poor	--	very poor	poor
Whispering	all	--	--	fair	good	good	good	--	--	poor	good	--	fair
Woodin	all	--	fair	fair	--	fair	good	--	--	--	fair	--	--

TABLE 5

SCHEDULE FOR IMPLEMENTING THE OXY MITIGATION PLAN

<u>MITIGATION MEASURE</u>	<u>DATE IMPLEMENTED</u>
<u>Aquatic</u>	
Storm drainage system	Summer 1982
Access Road Drainage and Graveling	Summer 1982
Plant Site Revegetation	Fall 1982
Access Road Revegetation	Fall 1982
<u>Wildlife</u>	
Controlled Burning	Begin January 1985
Limiting Access to Nonessential Trails	Spring 1982

TABLE 6

MONITORING SCHEDULE

<u>MITIGATION MEASURE</u>	Jan Feb	Mar Apr	May Jun	Jul Aug	Sep Oct	Nov Dec
Storm drainage system		X			X	
Access Road Gravelling and Drainage			X			
Plant Site Revegetation		X			X	
Access Road Revegetation		X			X	
Controlled Burning		X				
Limiting Access to Nonessential Trails			X			
Anderson and Gunning Creek(s) Water Quality Sampling		X	X		X	X
On-Site seep/spring		X			X	

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