Calpine Enhanced Geothermal Systems Project

Final Environmental Assessment

June 2010

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June 21, 2010

DOE/EA 1733

FINDING OF NO SIGNIFICANT IMPACT FOR THE PROPOSED CALPINE ENHANCED GEOTHERMAL SYSTEMS PROJECT WITHIN THE NORTHWEST GEYSERS, CALIFORNIA

AGENCY: Department of Energy, Golden Field Office

ACTION: Finding of No Significant Impact

SUMMARY: In accordance with the U.S. Department of Energy (DOE) National Environmental Policy Act of 1969 (NEPA) implementing regulations, DOE prepared an Environmental Assessment (EA) that analyzed the potential impacts associated with an Enhanced Geothermal System (EGS) demonstration project (Project). The Project would be located within the Northwest Geysers, Sonoma County, California within the Geysers-Clearlake Known Geothermal Resource Area (KGRA).

DOE, through its Golden Field Office, proposes to provide federal funding to the Calpine-Geysers Power Company (Calpine) for the Project. Granting of financial assistance for this project constitutes a major federal action as defined by NEPA. DOE must consider the possible environmental impacts from the Project before committing to provide funding. The EA evaluates the impacts of the No Action and the Proposed Action alternatives under the following impact areas:

- Air Quality
- Geology and Geothermal Resources
- Seismicity and Induced Seismicity
- Biological Resources
- Water Resources
- Noise
- Aesthetics and Visual Resources
- Human Health and Safety and Risk Assessment
- Cumulative Impacts

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All discussion, analysis and findings related to the potential impacts of construction and operation of the EGS demonstration project are contained in the Final Environmental Assessment (EA).The Final EA is hereby incorporated by reference.

The Proposed Action analyzed under this EA includes:

- Phase I: Pre-stimulation
    - Development of the stimulation plan for the proposed EGS concept
    - Construction of a pipeline spur to deliver water from the Santa Rosa Geysers Recharge Project (SRGRP) for injection to the PS-31 well pad
    - Re-opening of two wells (known as Prati State-31 (PS-31) and Prati-32 (P-32)) and performing the necessary well bore modifications (i.e., open and complete the selected wells and potentially deepen the wells)
- Phase II: Stimulation
    - Implementation of the stimulation
    - Monitoring and validation of the stimulated EGS system
- Phase III: Long Term Injection, Data Collection, and Monitoring
    - Continued injection, monitoring and validation of the sustainability of the EGS project

The EGS project would be located entirely on privately-owned surface lands within a mineral estate owned by the State of California, and private Fee Lands. Activities would only occur in previously disturbed areas (surface areas). The objectives of the project are to:

- Develop and demonstrate the stimulation methodologies to create an EGS in a deep, very hot fractured rock system by means of injection of treated wastewater at temperatures substantially lower than the formation.
- Investigate how the water injection affects the fractured rock system, both mechanically (e.g., cooling shrinkage and fracture shear reactivation) and chemically (e.g., dissolution) and how such processes contribute to EGS.

In accordance with applicable regulations and policies, DOE sent scoping notices to potentially interested federal, state, and local agencies, and published a notice in the local newspaper. DOE also mailed a scoping notice to adjacent property owners and posted the notice on the DOE Golden Field Office reading room website. The scoping letters described the Proposed Action and requested assistance in identifying potential

issues that could be evaluated in the EA. Consultations were also conducted with the local State Historic Preservation Office, U.S. Fish and Wildlife Office, and local Native American tribes.

DOE sent notices announcing the availability of the Draft EA for public comment to the same state, local, and federal agencies, representatives, businesses, and individuals that received the scoping notice. The Draft EA was made available for public review and comment on the DOE Golden Field Office reading room website.

One public comment letter was received on the Draft EA from the Friends of Cobb Mountain organization. The main concerns identified by the Friends of Cobb Mountain relate to the potential for seismic events; potential intensity of seismic events; effects of seismicity on the community; and that the analysis in the EA did not incorporate residents' testimony in regards to induced seismicity.

An analysis of community reaction to earthquakes was completed through an evaluation of hotline calls. The evaluation demonstrated that 6 percent of the earthquakes over M 2.0 that occurred between January 1, 2004 and August 31, 2009 (within 0.5 miles of the Calpine strong motion instrument) were felt, and of those, the vast majority occurred within 10 km of the community reporting the motion. This analysis of verbal testimony has been included in the Final EA (Appendix L). The analysis does not change any conclusions of the EA, and further serves to strengthen the conclusion that the project would not likely have a significant adverse effect to the communities. The project could induce small seismic events; however, the project is over 10 km from the nearest communities, and based on existing data from existing operations and earthquake monitoring, is not likely to produce earthquakes capable of damage to buildings or structures in the nearby communities. These findings are described in detail in the report entitled "Evaluation of the Environmental Impacts of Induced Seismicity at the Calpine Enhanced Geothermal System Project, The Geysers, California" included in the Draft and Final EA (Appendix I).

DOE has responded to the comments in the EA and determines the analysis to be thorough and complete. DOE determines that impacts related to these issues are less than significant in regards to the Proposed Action. A complete copy of the comments and responses to the concerns noted are included as Appendix L of the Final EA.

DETERMINATION: DOE determines that providing funding to support the construction and operation of the proposed EGS demonstration project within the Northwest Geysers, Sonoma, County, California, would not constitute a major Federal Action significantly affecting the quality of the human environment, as defined by the National Environmental Policy Act.

The applicant-committed measures identified in Chapter 2.8 (pp 2-21 to 2-26) of the EA shall be incorporated as conditions of funding in the DOE award documents. The measures include obtaining and complying with all required permits and minimizing potential impacts through the implementation of construction and operation Best Management Practices and other identified design features.

The preparation of an Environmental Impact Statement is not required and DOE is issuing this Finding of No Significant Impact.

All discussions and findings related to the project site and the Proposed Action are contained within the Final EA. Copies of the Final EA are available at the DOE Golden Field Office Public Reading Room website at:
http://www.eere.energy.gov/golden/Reading_Room.aspx, or from:

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Issued in Golden, Colorado this 21st day of June, 2010.

Carol Battershell
Acting Executive Director of Field Operations

Calpine Enhanced Geothermal Systems Project

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List of Acronyms

3D	3-dimensional
amsl	Above mean sea level
As	Arsenic
ATC	Authority to Construct
B	Boron
BEPA	Bald Eagle Protection Act
BMPs	Best management practices
BOPE	Blowout prevention equipment
CALNET	Central California Seismic Network
CARB	California Air Resources Board
CCPA	Central California Power Agency
CDF	California Department of Forestry
CDFG	California Department of Fish and Game
CDOGGR	California Department of Oil, Gas, and Geothermal Resources
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CH_4	Methane
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CO_2	Carbon dioxide
CWA	Clean Water Act
dB	Decibel
dBA	A-weighted decibel
DOE	Department of Energy
DWR	Department of Water Resources

EA	Environmental Assessment
EGS	Enhanced Geothermal System
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary significant unit
FEMA	Federal Emergency Management Agency
FOA	Funding Opportunity Announcement
GDMACDA	Geothermal drilling mud and cuttings disposal area
GHG	Green house gas
gpm	Gallons per minute
H_2S	Hydrogen sulfide
HFCs	Hydrofluorocarbons
Hg	Mercury
HMBP	Hazardous Material Business Plan
HTZ	High temperature zone
IRWP	Incremental Recycled Water Program
IS/MND	Initial Study/Mitigated Negative Declaration
LBNL	Lawrence Berkeley National Laboratory
MBTA	Migratory Bird Treaty Act
MEQs	Micro-earthquake activity
mg/L	Milligrams per liter
ML	Richter local magnitude
MPa	Megapascals
MW	Megawatt
N_2O	Nitrous oxide

NaOH	Sodium hydroxide
NCG	Noncondensible gases
NCSN	Northern California Seismic Network
NEPA	National Environmental Policy Act
NH_3	Ammonia
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NSCAPCD	North Sonoma County Air Pollution Control District
OSHA	Occupational Health and Safety Organization
P-32	Prati-32
PFCs	Perfluorocarbons
$PM_{2.5}$	Particulate matter 2.5 microns and smaller in diameter
PM_{10}	Particulate matter 10 microns and smaller in diameter
PPE	Personal protection equipment
ppm	Parts per million
PRMD	Permit and Resource Management Department
PS-31	Prati State-31
PTO	Permit to Operate
PTS	Pressure temperature spinner
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
SF_6	Sulfur hexafluoride
SHPO	State Historic Preservation Office
SPCC	Spill Prevention Control and Countermeasure
SRGRP	Santa Rosa Geysers Recharge Project

SWPPP	Stormwater Pollution Prevention Plan
TDS	Total dissolved solids
UCB	University of California at Berkeley
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
VOCs	Volatile organic compounds
WDP	Waste Discharge Permit
WSA	William Self Associates

1: Overview of the Project

1.1 Introduction

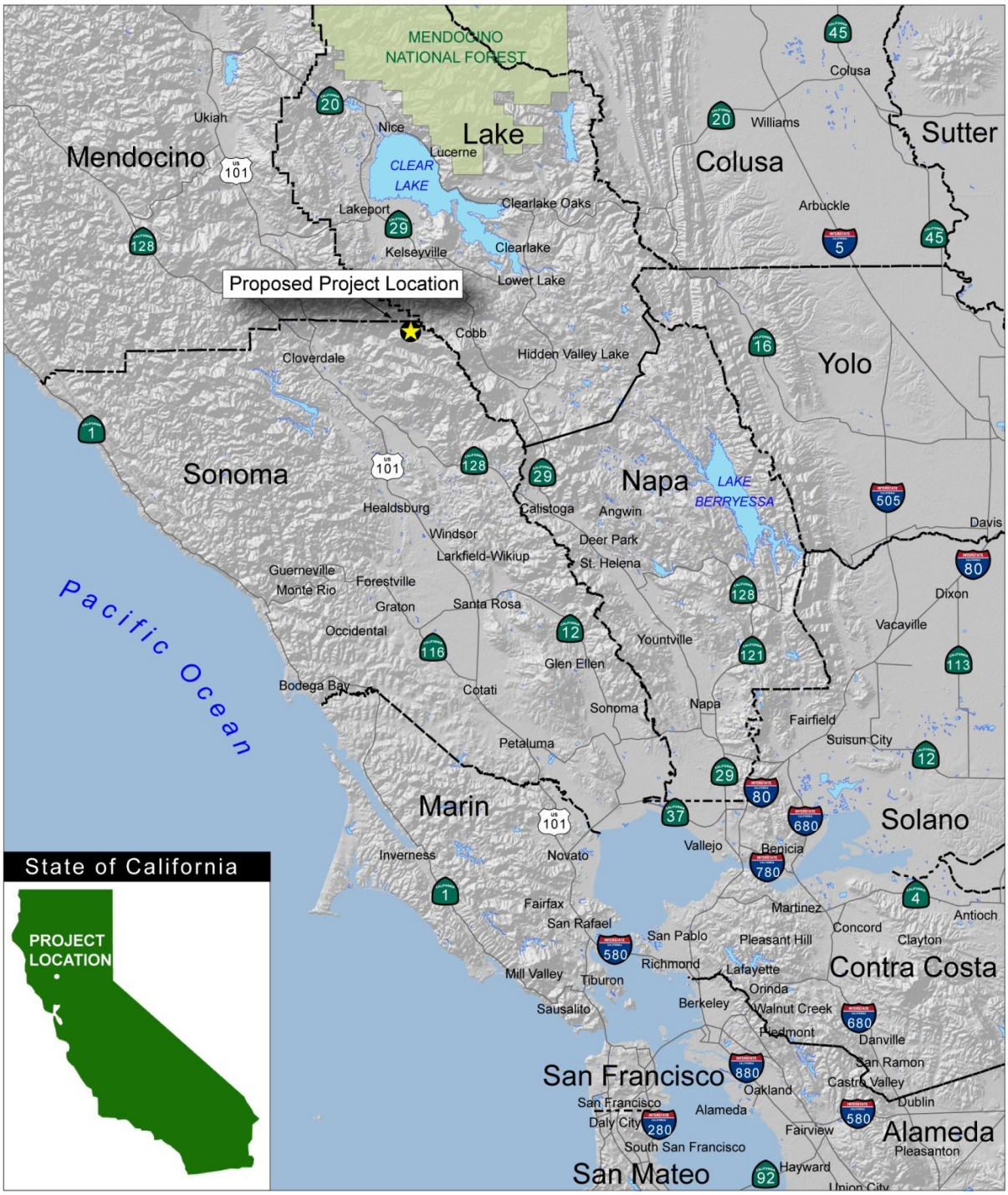
The US Department of Energy (DOE) is preparing an Environmental Assessment (EA) to address the potential environmental effects of the Calpine-Geysers Power Company (Calpine)'s proposed Enhanced Geothermal System (EGS) demonstration project. The proposed project would be located within the Northwest Geysers, Sonoma County, California (Figure 1.1-1, 1.1-2, and 1.1-3) within the Geysers-Clearlake Known Geothermal Resource Area (KGRA).

The proposed EGS project includes the injection of water, ranging from 50 to 80 degrees Fahrenheit, into wells to enhance the permeability of an existing high temperature hydrothermal reservoir that would be harnessed to produce electrical energy. The purpose of the project is to demonstrate the ability to stimulate high temperature rocks by monitoring their early response to carefully designed injection tests. The project would be a collaborative effort between scientists and engineers of Calpine Corporation, Lawrence Berkeley National Laboratory (LBNL), and the DOE. The proposed project includes the following phases:

- Phase I: Pre-stimulation
  - Development of the stimulation plan for the proposed EGS concept
  - Construction of a pipeline spur to deliver water from the Santa Rosa Geysers Recharge Project (SRGRP) for injection to the PS-31 well pad
  - Re-opening of two wells (known as Prati State-31 (PS-31) and Prati-32 (P-32)) and performing the necessary well bore modifications (i.e., open and complete the selected wells and potentially deepen the wells)
- Phase II: Stimulation
  - Implementation of the stimulation
  - Monitoring and validation of the stimulated EGS system
- Phase III: Long Term Injection, Data Collection, and Monitoring
  - Continued injection, monitoring and validation of the sustainability of the EGS project

In response to a 2008 Funding Opportunity Announcement (FOA), DOE would provide financial assistance for the proposed project. Granting of DOE financial assistance for this project would constitute a major federal action as defined by the National Environmental Policy Act of 1969 (NEPA). DOE must consider the possible environmental impacts from the project before committing to provide funding. In accordance with the provisions of NEPA and the Council on Environmental Quality (CEQ) and DOE implementing regulations, DOE has determined that an EA must be completed for the proposed project to evaluate the potential environmental impacts that could result from the award of the funding.

Figure 1.1-1: Regional Location Map



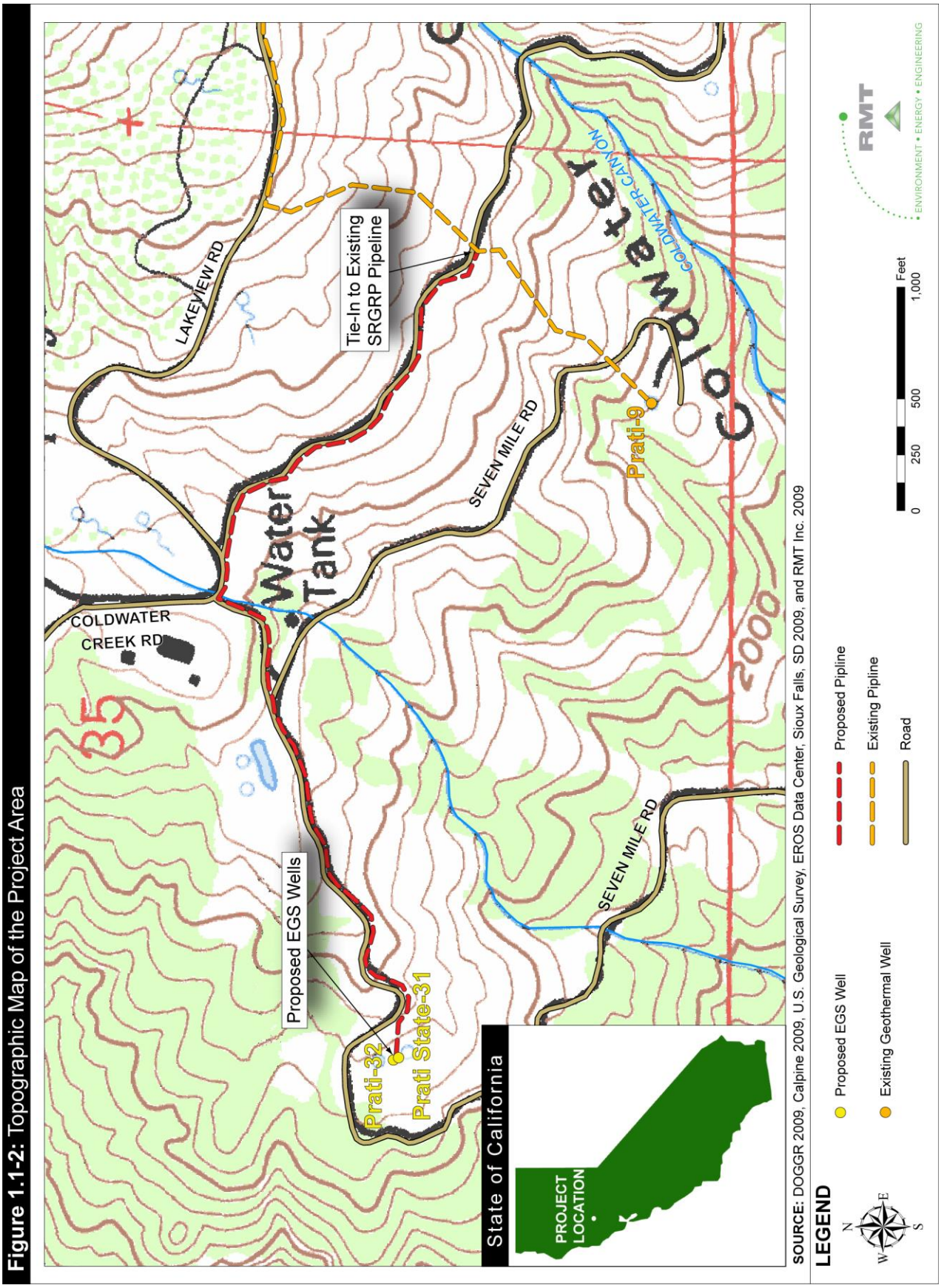
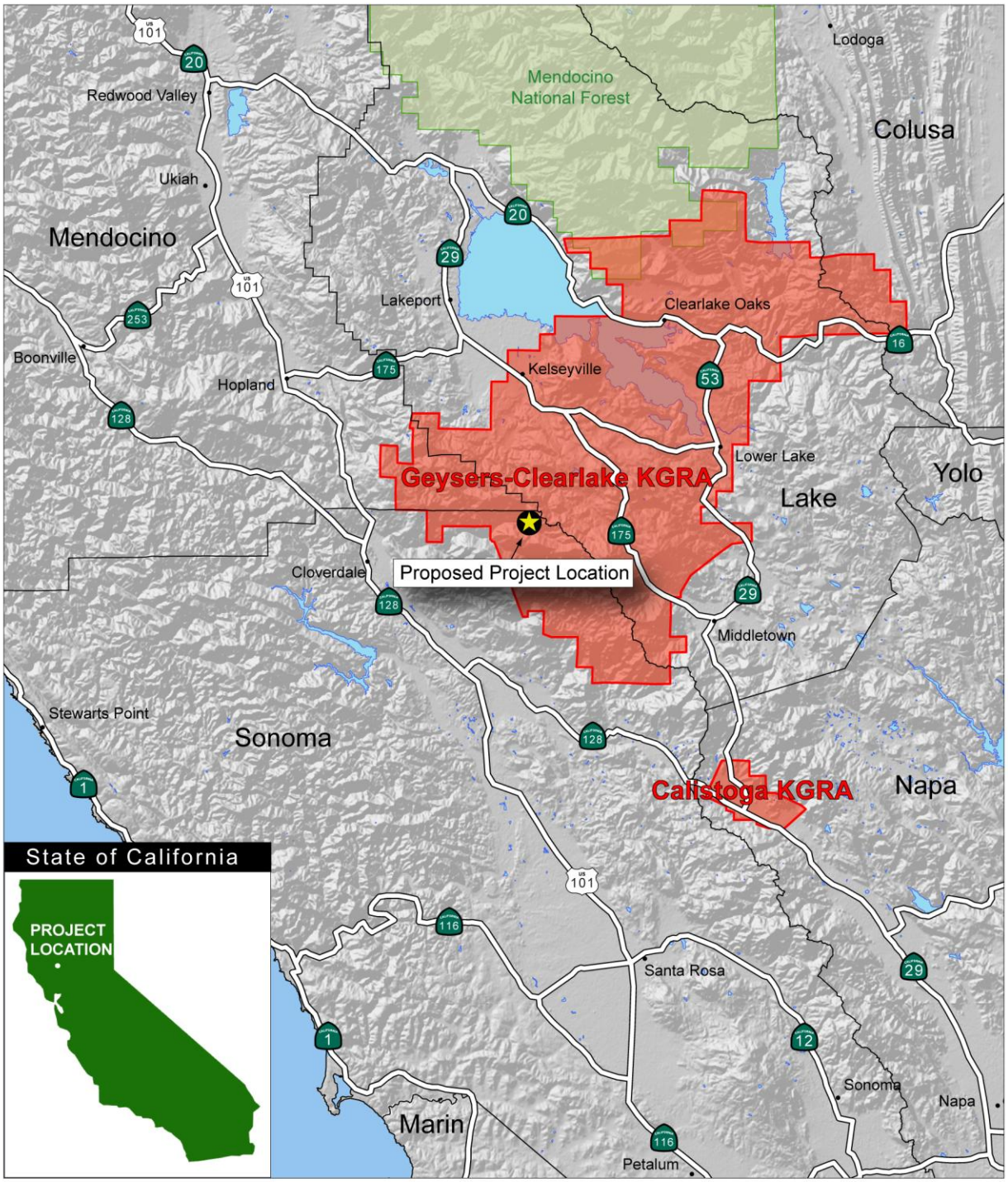


Figure 1.1-2: Topographic Map of the Project Area

Figure 1.1-3: Geysers-Clearlake KGRA



SOURCE: Google Earth Pro 2009, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 2009, and RMT Inc. 2009

LEGEND

- Project Location
- U.S. Highway
- State Route
- Known Geothermal Resource Area (KGRA)
- National Forest

Miles: 0, 5, 10, 20

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This EA has been prepared in accordance with the requirements of NEPA. The DOE Golden Field Office Manager would make the decision concerning this proposed project.

1.2 Purpose and Need

The DOE's proposed action is to provide financial assistance to Calpine in support of the development of the proposed EGS project. Recent growth in electricity has created the need for alternative sources of power. Renewable energy sources, such as geothermal energy, already supply a reasonable amount of energy in western states, especially California. The Geothermal Steam Act of 1970 encouraged geothermal development as a means of diversifying energy supplies in the United States. In April 2008, former President Bush announced a national goal to stop the increase in greenhouse gas (GHG) emissions by 2025. By providing financial assistance to support this project, DOE would support California and the United States in reaching their goals by offsetting some of the need for non-renewable energy sources that produce GHG emissions.

Calpine's proposed project would demonstrate the technology required to extract energy from high temperature, low permeability zones within the earth. The purpose would be to establish and document the feasibility of stimulating the productivity of high temperature rocks by monitoring their early response to carefully designed injection tests. The project would include initially studying highly productive areas within The Geysers (once known locally as the "Big Geysers") to determine the historic evolution of the EGS. Data collected from the initial studies would contribute to the creation of a similar EGS at the proposed site, which is an area of relatively low natural (unstimulated) permeability compared to other portions of The Geysers. Successful demonstration of the technology and methodology has the potential to increase the production of geothermal energy at The Geysers by as much as 300 megawatts (MW).

The Geysers is a suitable location for the creation and monitoring of an EGS project because of its existing infrastructure of wells, pads, access roads, available injection water, and a functioning microseismic array to monitor the early response to injection tests within the proposed EGS demonstration area.

1.3 Public Involvement

Comments on the scope of this EA were sought from the public, regulatory agencies, and other interested parties as part of the NEPA process. A letter describing the scope of the project was sent out to all parties on the project's distribution list on December 11, 2009 (Appendix A). Copies of the letters, distribution list, and responses are included in Appendix A to this EA. All comments were considered in the Pre-Decisional Draft EA.

A letter was sent by DOE to the several tribes within California to initiate a nation-to-nation consultation. The list of tribes that received the letter is also included in Appendix A.

The US Fish and Wildlife Service (USFWS) and the California State Historic Preservation Office (SHPO) have been contacted per requirements of Section 7 of the Endangered Species Act (ESA) and Section 106 of the National Historic Preservation Act (NHPA).

The Draft EA was also duly noticed to adjacent contiguous property owners and interested parties as identified by DOE and the notice was posted on the DOE Golden Field Office reading room web site. DOE received one letter of comment on the Draft EA from the Friends of Cobb Mountain organization. The comments and responses to the concerns noted are included in Appendix L of this Final EA.

1.4 Organization of this EA

This EA has been prepared pursuant to NEPA and DOE guidelines and:

- Describes the existing environment,
- Presents an analysis of the environmental consequences of the proposed project,
- Describes the effects of the no action alternative, and
- Addresses any concerns expressed by interested parties.

The information presented in this environmental analysis was obtained from personal communications with interested parties, background data and information on the project and similar projects, and environmental reports for similar projects in and around The Geysers. References used in preparation of this document are included in Appendix B. A list of persons and agencies contacted is presented in Appendix C.

2: Proposed Action and Alternatives

2.1 Overview

This chapter describes the Proposed Action and the No Action Alternative. The Proposed Action consists of the DOE's decision to provide funding through its Geothermal Technologies Program for the proposed EGS to be created by Calpine in the Northwest Geysers, California.

The No Action Alternative is described in Section 2.5. No other alternatives were considered since all potential impacts from the project can be minimized.

2.2 Project Location

The proposed project area is located in the northeastern portion of Sonoma County near the Lake County and Mendocino County borders.

The project components would be located in the northwest corner of Section 35, Township 12 North, Range 9 West, Mount Diablo Meridian. The project site is located within an undeveloped 10 square-mile area of the Northwest Geysers between the Aidlin and Ridgeline Power Plants (Units 7 and 8). The proposed project would reopen and convert two existing wells: PS-31 and P-32, as shown in Figure 2.2-1. The project also includes the extension of the SRGRP pipeline from the existing tie-in near the Prati 9 well, for a length of 1 mile, to the EGS wells.

The EGS project would be located entirely on privately-owned surface lands within a mineral estate owned by the State of California, and private Fee Lands. Activities would only occur in previously disturbed areas (surface areas).

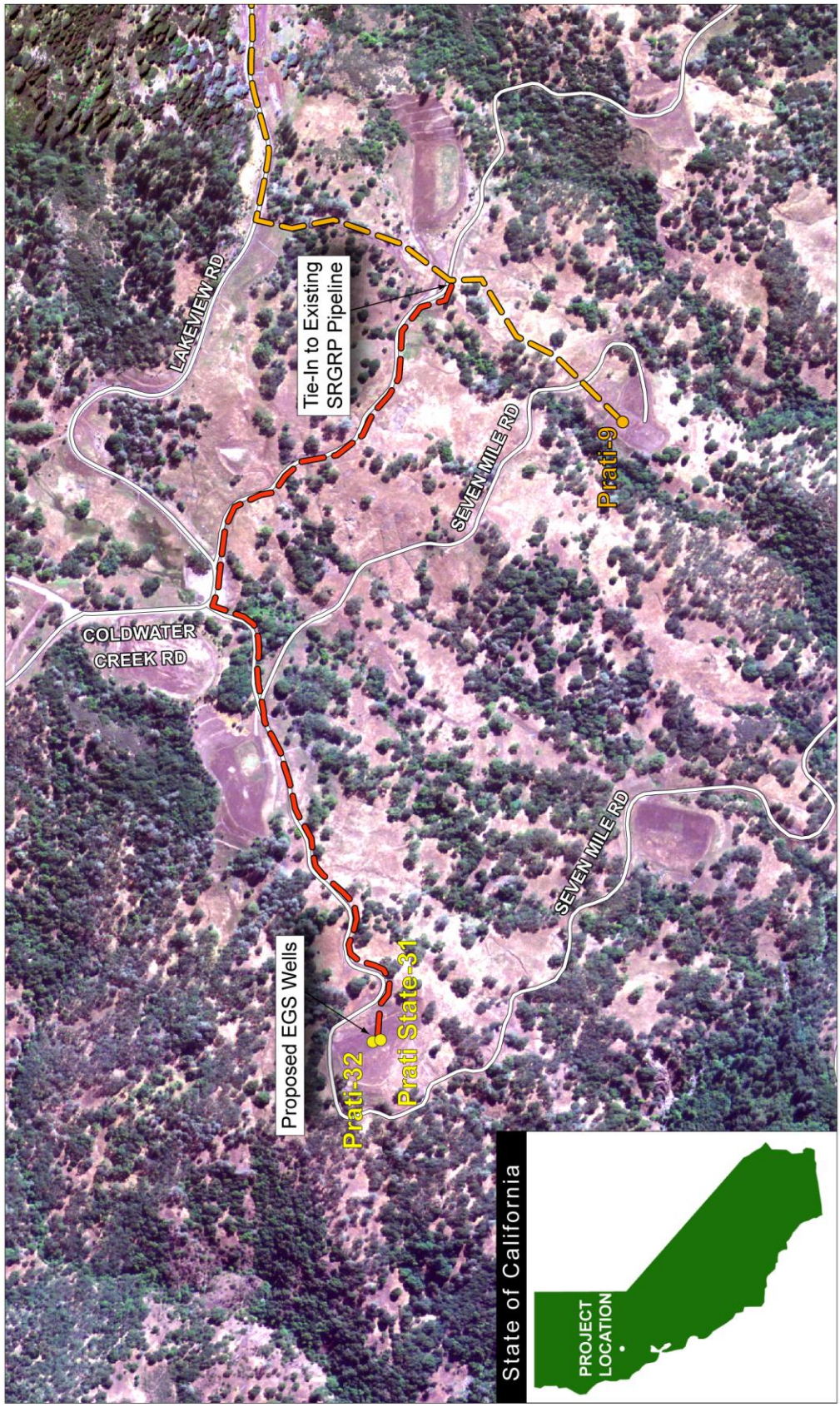
2.3 Project Background

2.3.1 DEVELOPMENT OF THE GEYSERS

The first commercial geothermal wells were drilled at The Geysers in 1955 by Magma Power Company. Construction of the first commercial power plant began in 1960 for an 11 MW plant. An average annual generation of 2,000 MW was being produced by 1987. Calpine acquired most of the plants at The Geysers by 1999; however, the production at The Geysers was on a slow decline since the daily power output at The Geysers peaked at 2,000 megawatts in 1987. Supplemental injection programs using recycled wastewater countered the decline.

Supplemental water was brought to The Geysers in 1997 with the implementation of the Lake County-Southeast Geysers Effluent Pipeline Project. The project was the first recycled-water-to-electricity project in the world. The 29-mile underground pipeline delivers 8 million gallons of treated reclaimed water per day to The Geysers to be injected into the geothermal reservoir. The SRGRP was selected in 1998 to bring an additional 11 million gallons of treated recycled water per

Figure 2.2-1: Location of Proposed EGS Injection Wells and Proposed Pipeline



SOURCE: DOGGR 2009, Calpine 2009, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 2009, Lake County, Sonoma County 2000, and RMT Inc. 2009

LEGEND

- Proposed EGS Well
- Existing Geothermal Well
- Proposed Pipeline
- Existing Pipeline
- Road

N W E S

0 250 500 750 1000 Miles

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day to The Geysers through an underground pipeline. The SRGRP was selected for implementation after extensive environmental review. The City of Santa Rosa completed both the California Environmental Quality Act (CEQA) process and the NEPA process prior to selecting the SRGRP. The SRGRP project was built and began delivering water to injection wells in The Geysers in 2003. An Addendum to the CEQA Environmental Impact Report (EIR) that evaluated the impacts of increasing recycled water deliveries to The Geysers steam field up to an annual average of 19.8 million gallons per day was approved by the City of Santa Rosa on August 14, 2007. Coverage area of the Addendum included the proposed EGS steam field project area.

2.3.2 PROPOSED EGS DEVELOPMENT AREA

The proposed EGS project would be developed and demonstrated in an area of the Northwest Geysers, which was originally explored in the 1980s. The exploratory drilling in the early 1980's revealed a relatively shallow (~8,500 feet) high temperature (>500°F) zone (HTZ) in low permeability rock below the known Geysers steam reservoir. Figure 2.3-1 is a schematic of the EGS reservoir and the normal temperature reservoir. Although the enthalpy (total heat) of the steam produced from the HTZ is very high, the chemical quality of the steam is poor because of very high concentrations (4.0 to 7.5 weight percent) of noncondensable gasses (NCG), and highly corrosive hydrogen chloride gas. This poor quality steam remains unusable for electrical generation because of functional, economic, and environmental restraints.

Calpine proposes to re-open two of the original exploratory wells that penetrate the HTZ and convert them to deep injection wells to stimulate the production of usable quality steam for electrical generation.

The two proposed abandoned exploration wells (PS-31 and P-32) would require a small amount of deepening to penetrate the HTZ. PS-31 is currently 9,000 feet deep and may need to be deepened by approximately 500 feet. P-32 is currently 9,600 feet deep and is not expected to need further deepening. An extension [1.0 miles in length (5,320 feet)] of the SRGRP pipeline whose present terminus is at the Prati -9 well would provide an ample supply of injection water. Based on historical experience at The Geysers, the injection is expected to lower the NCG concentrations in the steam produced, stimulate fracturing in the HTZ, and provide a sustainable flow of usable quality steam to nearby steam wells.

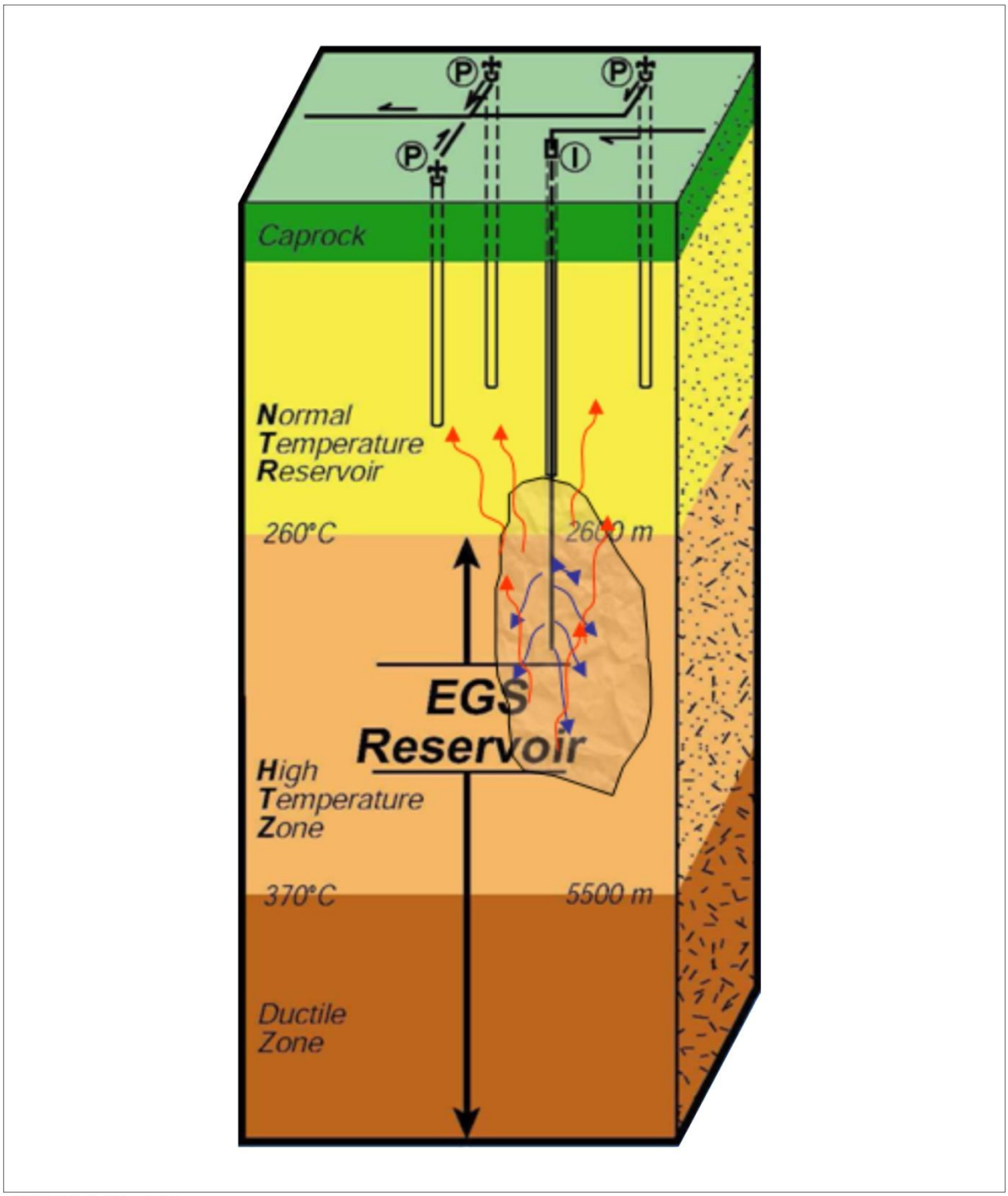
Calpine has successfully re-opened three other abandoned wells in the area, Prati-9 (November 2007), Prati State-10 (September 2009), and Prati State-54 (August 2007).

2.3.3 PROJECT OBJECTIVES

The objectives of the project are to:

- Develop and demonstrate the stimulation methodologies to create an EGS in a deep, very hot fractured rock system by means of injection of treated wastewater at temperatures substantially lower than the formation.
- Investigate how the water injection affects the fractured rock system, both mechanically (e.g., cooling shrinkage and fracture shear reactivation) and chemically (e.g., dissolution) and how such processes contribute to EGS.

Figure 2.3-1: Schematic of Geothermal Temperature Zones and EGS Reservoir



SOURCE: Calpine 2009

Heated Geothermal Steam

Cold Water

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- Demonstrate the technology to monitor and validate the stimulation and sustainability of such an EGS.
- Develop an EGS research field laboratory site that can be used for testing EGS stimulation and monitoring technologies including new high temperature logging tools.

2.4 Proposed Action

2.4.1 OVERVIEW OF THE PROPOSED ACTION

As discussed in Chapter 1, the DOE proposes to fund Calpine's EGS project. The proposed project includes three phases:

- Phase I: Pre-stimulation
- Phase II: Stimulation
- Phase III: Long Term Data Collection and Monitoring

The project would use water supplied by the SRGRP via a pipeline extension of 1.0 miles that would be installed along Seven Mile and Squaw Creek Roads, which are existing roads, already graded with road base and in adequate condition to service the proposed project. The project would include re-opening abandoned exploration wells on an existing pad, with access via existing roads. No new ground surface disturbance in previously undisturbed areas is proposed.

Monitoring of the EGS project would occur using Calpine's extensive existing seismic monitoring network, which are currently used to monitor the SRGRP. Four monitoring stations that are currently being developed as part of another project would also be available by the time the proposed project would be implemented.

2.4.2 PHASE I: PRE-STIMULATION

Overview

The focus of the pre-stimulation phase would be to develop a stimulation plan for the EGS area. This would include:

- Creation of a complete 3-dimentional (3D) geologic model of the EGS area.
- Analysis of the historic induced seismicity within the most productive area in The Geysers.
- Pre-stimulation modeling of the selected EGS wells.
- Construction of the water supply pipeline (SRGRP pipeline spur).
- Preparation of the well pad and access roads.
- Performing the necessary well bore modifications such as opening and completing the selected wells and potentially deepening the selected wells.
- Install injection system equipment.

Creation of 3D Geologic Model

The stimulation plan would be developed by creating a complete geological model of the EGS area. The EGS area has already been well characterized. There are numerous data logs and field

data for the project wells (PS-31 and P-32), as well as other nearby wells, that would be synthesized during the pre-stimulation phase to create a 3D geologic model of the EGS area. Data to be evaluated includes:

- Drilling rate (a measure of variation in mechanical properties)
- Drilling mud logs (well bore lithology and identification of steam bearing fractures)
- Caliper logs (borehole break-out can be used to constrain stress field and mechanical properties)
- Pressure temperature spinner (PTS) and spinner log data (to identify hydraulic conducting fractures)
- PTS data in flowing steam (to identify steam producing fractures)
- Bottom hole thermometer measurements made during drilling (the best available measure of formation temperature)
- Temperature of drilling air return
- Logs of H2O and CO2 while drilling (a distinct indicator of the HTZ boundary)

Analysis of Historic Induced Seismicity

The next step would include performing an analysis of the existing injection-induced EGS in The Geysers steamfield. LBNL and Calpine would study the historic evolution of injection and induced seismicity in this area. The area of interest within The Geysers is located within an extent of the HTZ and to the southeast of the proposed EGS area. The injection and evolution of induced seismicity (an indicator of fracture shear reactivation) would be analyzed using tools for stimulation planning, design, and validation (i.e., coupled reservoir-geomechanical modeling techniques), and would be supported and corroborated by analysis of field data, including 3-D tomography (imaging by sections or sectioning through the use of wave energy) and high precision location of earthquakes, satellite based measurements of surface deformations, and chemical isotope analysis of production fluids.

Pre-Stimulation Modeling of PS-31 and P-32

This step would include modeling of stimulation at two scales: (1) stimulation of the well bore (e.g., cooling fracturing of the well connecting with nearby pre-existing fractures) and (2) simulation of the fracture network by shear reactivation to create a substantial EGS volume around the injection well.

Construction of Injection Water Supply Pipeline

System Construction

Pipeline Construction

The project would include construction of a 1.007 mile long water supply pipeline that would be connected into PS-31 and P-32 for injection. The pipeline would be constructed prior to re-opening of the wells in order to supply drilling water to the wells. The pipeline would be built as an extension from the existing SRGRP pipeline, as shown in Figure 2.2-1. The pipeline would be 10 inches in diameter from its existing tie in point, to a future tie-in located approximatley 600 feet

east of the well pad. A metering station would be installed at this tie-in location. The remaining 600-foot length of pipeline to PS-31 and P-32 would be constructed of 6-8 inch diameter pipe. A general decrease in elevation from approximately 2,510 feet to 2,128 feet occurs from the tie-in point to PS-31 and P-32.

The pipeline would be constructed on stanchions within the shoulder of existing roads. The pipeline would be non-reflective and would be colored to match the terrain. Plan drawings for the pipeline are included in Appendix E. The pipeline would include tap points, control valves, and a drain assembly on sleeper supports. One approximately 20 foot tall road crossing vertical loop would be required.

The pipeline would be constructed with trucks and side booms. Supports would be constructed using drilled and poured pier foundations. If the soils within which the stanchions are constructed are determined to be expansive, then the Standard Engineering Methods for Expansive Soils would be employed. These methods include:

1. Removal of native soil and replacement with an engineered fill material not prone to shrinking and swelling.
2. Soil stabilization, such as lime treatment to alter soil properties to reduce shrink-swell potential to an acceptable level.
3. Deepening footings or other support structures in the expansive soil to a depth where soil moisture fluctuation is minimized.

Construction corridors would be confined to the roadway and no new ground disturbance would occur. Travel outside the construction corridors would be strictly limited to designated turnout areas (to be identified) and access roads.

All work would occur in the existing roadway and would not require disturbance of previously undisturbed areas. The pipeline would connect beyond the road into another well pad (Prati-25), but would remain on previously disturbed areas (i.e., the well pad or the road). The pipeline would be tested in accordance with engineering standards; however, no discharge of water to the surface would occur during or after the hydrostatic testing of the pipeline.

Staging, Personnel, and Schedule

Staging would occur along the road and at the well pad. Pipe would be stored only in approved, previously disturbed, staging areas.

Construction of the pipeline would require about 5-8 construction workers and would take approximately 6-8 weeks to complete.

Water Supply

Potable water would be delivered to the site for consumption purposes during pipeline construction. Sanitary facilities would be provided and maintained by a licensed local contractor. Water for dust suppression, if required, would be from water wells or tertiary treated recycled water from the SRGRP.

Waste Disposal

Wastes generated during pipeline construction could include soils and vegetation, as well as construction waste (i.e., packaging). This material would be disposed at an appropriate facility. No hazardous wastes are expected.

Preparation of Well Pad and Access Roads

Pad and Road Preparation

The two wells proposed for modification are located on an existing well pad. The last time this pad was used for operating wells was in 1996, before the two subject wells were abandoned in 2000. Approximately one day of re-grading work would be performed on the pad to prepare it for drilling equipment. The pad is approximately 2 acres in size. Re-grading would entail preparing a perimeter earthen berm, closing off drainage culverts and installing sub-grade water collection points for the retention of storm water and as a contingency for spills from the drilling operation. A layer of gravel is also provided in the work area.

Set up of the pad would primarily be required for mobilizing the equipment and drill rig. The pad would be accessed via Seven Mile and Squaw Creek Road, which is an existing road already graded with road base.

Staging, Personnel, and Schedule

Minimal staging would be required for preparation of the well pad and access road. Any staging required would occur on the well pad.

An estimated four crew members would be involved in well pad activities, which would take approximately four days to complete.

Water Supply

Potable water would be delivered to the site for consumption purposes during pad re-grading. Sanitary facilities would be provided and maintained by a licensed local contractor. Water for dust suppression, if required, would be from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP.

Waste Disposal

Wastes generated during well pad grading and road preparation could include soils and vegetation. This material would be disposed of at an appropriate facility. No hazardous wastes are expected.

Well Bore Modifications

Process to Modify Well Bore

PS-31 and P-32 were drilled between 1983 and 1985. They were operated by the Central California Power Agency (CCPA) until the CCPA Power Plant was closed and abandoned in 1999 - 2000.

PS-31 and P-32 have typical completions as summarized in Table 2.4-1. Schematics and well histories for PS-31 and P-32 are shown in Figures 2.4-1 through 2.4-4. The re-opening of an abandoned well requires the steps described below.

Unplugging the Well

The abandoned casing cut-off below the ground surface would be found and the casing strings would be rebuilt to the surface. A new well head would then be installed on the 13 inch casing. The wells were previously abandoned with cement plugs. The three cement abandoned plugs would be cleaned-out in the 13 inch tieback and 11¾ inch cemented liner, and pressure tests would be conducted after the removal of each plug. A casing caliper log to determine casing condition would be run. A 7 inch packer/cement retainer located above the production liner shoe would be removed.

Re-Opening and Well Completion

Re-Opening - Re-opening is the process of physically re-opening the hole. The well would be re-opened, deepened, and completed for injection using a large rotary drill rig. During drilling, the top of the drill rig mask may be as tall as 135 feet above the ground surface. A photograph of a typical drill rig is shown in Figure 2.4-5. The rig would be equipped with diesel engines, fuel, and drilling mud storage tanks, mud pumps, and other ancillary equipment. Metal mixing tanks would be used to mix water and drilling mud. Tankage for an estimated 40,000 gallons of mud would be needed. The well would be re-drilled using air and/or mud to circulate the drill cuttings to the surface.

Table 2.4-1: Well Completion Features and Depths for PS-31 and P-32

Casing size	Depth
PS-31	
13-3/8 inch production casing	2705 feet
9 5/8 inch production casing liner	5720 feet
8-3/4 inch open hole	9,000 feet
P-32	
16 inch production casing	2993 feet
11-3/4 inch production liner tied back with a 12-3/8 inch casing	6113 feet
10-5/8 inch open hole	9600 feet

SOURCE: Calpine 2009

Figure 2.4-1: Schematic of PS-31

WELL HISTORY:

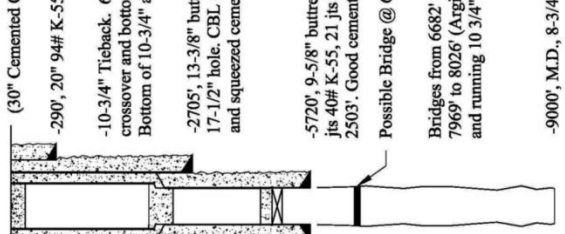
11/24/83-1/20/84: Drilled and completed well. CBL showed cement up to 1215' in 13-3/8" annulus, had to perf and squeeze cement. Clean out bridges at 6682'-6700' and 7969'-8026' after running 10-3/4" tieback.

2/27/84: Production test yielded 109 KPH at 369deg.F and 149 psig after 75 hours. Well never put on production, capped with nitrogen.

1992: USGS temperature and pressure logs run. Well thought to be bridged at 6134'.

1/11/00-1/15/00: Well P&A'ed.

SCHEMATIC



DESCRIPTION

(30" Cemented Conductor to 58' in 36" hole Not Shown)

-290', 20" 94# K-55. 26" hole. Cemented.

-10-3/4" Tieback. 60 jts 45.5# K-55 10-5/8" with 9-5/8"x10-5/8" crossover and bottom 2 jts 9-5/8" 40# K-55 stabbed in at 2503'. Bottom of 10-3/4" at 2425'. Good cement job.

-2705', 13-3/8" buttress casing, 6 jts 68# K-55, 64 jts 61# K-55. 17-1/2" hole. CBL showed cement up to 1215', perfed at 1212' and squeezed cement.

-5720', 9-5/8" buttress casing, 12 jts 40# SS95, 24 jts 40# N80, 22 jts 40# K-55, 21 jts 36# K-55. 12-1/4" hole. Hung on 13-3/8" at 2503'. Good cement job.

Possible Bridge @ 6134' (70% Argillite)

Bridges from 6682' to 6700' (Argillite Melange) and 7969' to 8026' (Argillite Melange) cleaned out after killing well and running 10 3/4" tie back.

-9000', M.D., 8-3/4" open hole. (8695.5' T.V.D.)

STEAM ENTRIES

5# @ 6910' 3# @ 7360' 20# @ 7955'
128# @ 6963' 29# @ 7708' 12# @ 7983'
2# @ 7160' 29# @ 7720' 50# @ 8242'
6# @ 7236' 3# @ 7760' 20# @ 8254'
3# @ 7336' 8# @ 8946'

HTZ

SIDE TRACKS

None

REMEDIAL WORK

NONE

LOST CIRCULATION ZONES

1630'-1660' 23 bbls
5723' 200 bbls

MISCELLANEOUS

RIG: Brinkerhoff Signal Rig #83

LOCATION: 3921' South and 1046' East the Northwest Corner of Section 35, T12N, R9W, M.D. B&M.

B.H.: 1376.9' South and 1085.4' West from surface location.

rev 6/29/09 MCW

CALPINE

Prati State 31

PLUGGED AND ABANDONED

GROUND ELEVATION	: 2116'	SPUD DATE	: 11/26/83	T. M. DEPTH	: 9000'
KELLY BUSHING	: 32'	COMPLETION DATE	: 1/17/84	T. V. DEPTH	: 8696'
TOTAL FOOTAGE	: 9000'	RIG TEST	: 146,000 #/hr., 106 psig.	E. T. DEPTH	: 9000'

SOURCE: Calpine 2009

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Figure 2.4-2: Schematic and History of Well P-32

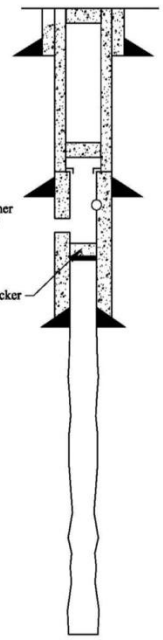
WELL HISTORY:

1-3-85 : Complete original well. Well suspended after rig test.

12/13/99: Casing caliper tool set down at 3050' (depth of milled area).

1/10/00: Well plugged and abandoned. Cement plugs at surface to 100', 2611-2773', 5600-5865'.

SCHEMATIC



DESCRIPTION

(30" Cemented Conductor Not Shown)

-322', 26" Hole, 22" 86.6# Line Pipe. Cemented.

-2805', Tieback, 13-3/8" 61# K-55 (73 jts) at 2713', with 11-3/4"x 13-3/8" crossover & 2- 11-3/4" stab in joints. Good cement job.

-2993', 20-1/2" Hole, 16-1/8" 95.6# N-80 (13 jts), 16" 84# K-55 (17 jts), 16" 75# K55 (41 jts) Casing. No cement returns to surface, top job to 327'.

-6113', 14-3/4" Hole, 11-3/4" 54# K-55 (17 jts), 60# K-55 (26jts), 60# N-80 (21 jts), 60# SS-95 (14jts) Casing. Little to no cement returns. Hung on Midway 16x11-3/4" double slip hanger at 2805'. **(SEE ORIGINAL WELL COMPLETION)

Swedged and milled collapsed liner at 3047' resulting in hole. Unintended sidetrack (481') through hole. Cement back hole.

-7045'-7060', Bridges in melange after testing well.

-9600', M.D., 10-5/8" Open Hole.

STEAM ENTRIES		HTZ
14# @ 6862'	4# @ 8226'	8# @ 9027-34'
10# @ 6924'	20# @ 8230'	53# @ 9370'
13# @ 8042'	5# @ 8275'	5# @ 9393'
14# @ 8062'	7# @ 8283'	5# @ 9570'
2# @ 8201'	7# @ 8325'	
5# @ 8215'		

SIDE TRACKS

Inadvertently sidetracked well a distance of 481' due to collapsed liner at 3047'. Cemented off sidetrack.

REMEDIAL WORK: No Work Overs.

LOST CIRCULATION ZONES

5380-5420', 30bbls/hr added LCM
5673', 30bbls/hr added LCM
5716', 160bbls/hr added LCM
5747-5773', 50bbls/hr set cement plug

MISCELLANEOUS

RIG: Loffland #306
LOCATION: 1036' East and 3898' North of the Northwest Corner of Section 35,T12N, R9W, M.D. B&M.
B.H.: 323.4' North and 1067' West from Surface Location.

ORIGINAL WELL COMPLETION:
1. 11-3/4" liner collapsed during cementing of 13-3/8" tieback due to hydrostatic pressure below Pic Pac cement retainer set at 3027'. The collapsed casing was milled out leaving a hole from 3044' to 3057' in the 11-3/4" liner.
2. 13-3/8" tieback was made using Midway 11-3/4" stab-in, 2 jts of 11-3/4" 54# K-55 casing, 11-3/4" insert float, 11-3/4" X 13-3/8" cross-over, and 73 jts of 13-3/8" 61# K-55 casing (total: 2820.9') stabbed into liner hanger at 2805'.
3. Rig test without 13-3/8" tieback = 187,700 lbs/hr, 472°F and 140 PSI with a 6" orifice. Rig test with 13-3/8" tieback = 134,800 lbs/hr, 407°F and 147 PSI with a 5" orifice. Shut-In Pressure of 448 PSI after 16 hours on 1/4" bleed.
4. Bridges after reaching T.D. and Testing: 7045'-7060'.
5. Bottomhole location closure: 1114.93' at North 73 degrees 8 minutes West.

CALPINE

Prati 32
API #097-90630
PLUGGED AND ABANDONED

GROUND ELEVATION	2116'	SPUD DATE	9/29/84	T. M. DEPTH	9600'
KELLY BUSHING	29'	COMPLETION DATE	1/3/85	T. V. DEPTH	9470'
TOTAL FOOTAGE	9600'	RIG TEST	134,800 #/hr, 147 psig	E. T. DEPTH	9600'

SOURCE: Calpine 2009

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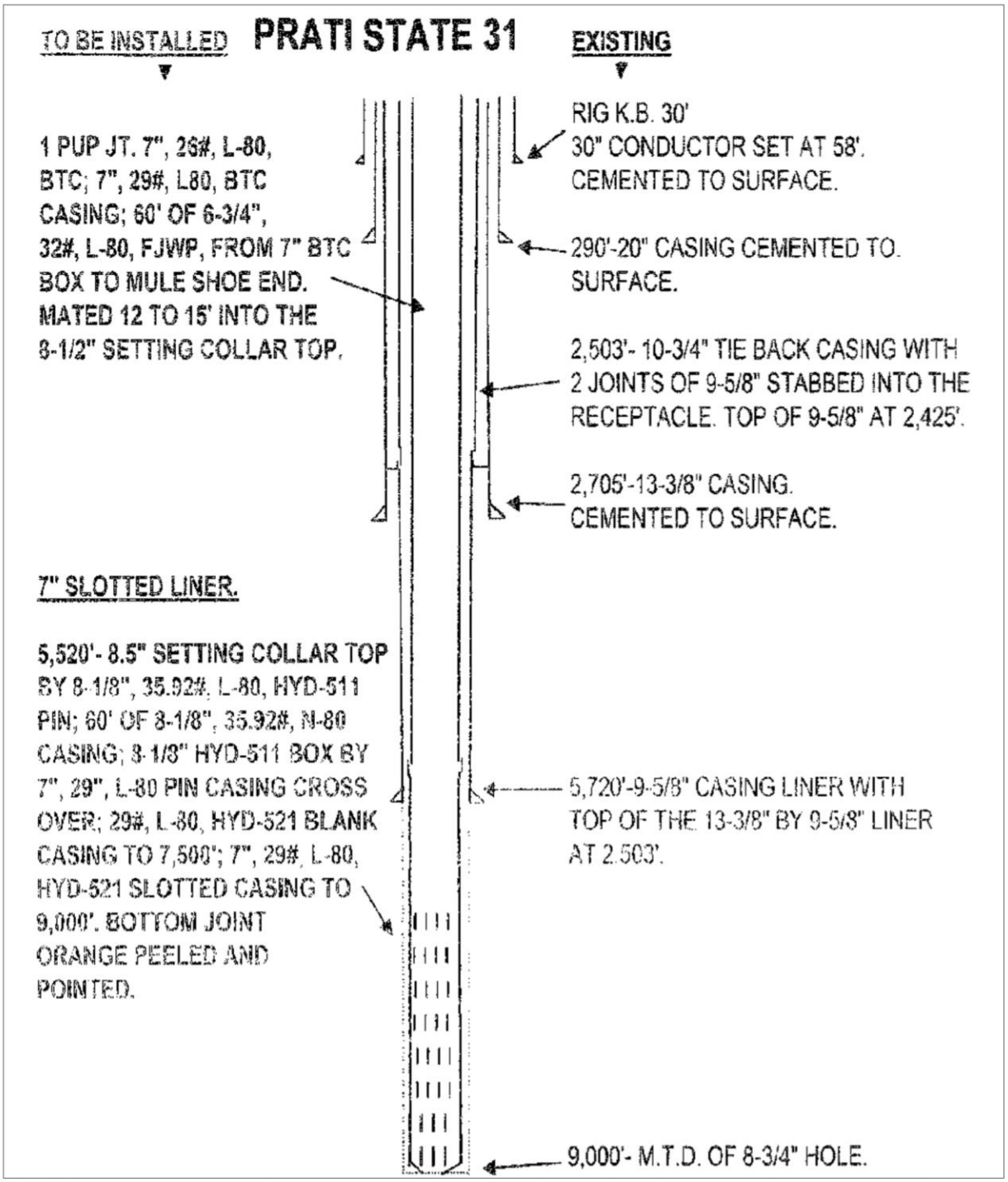
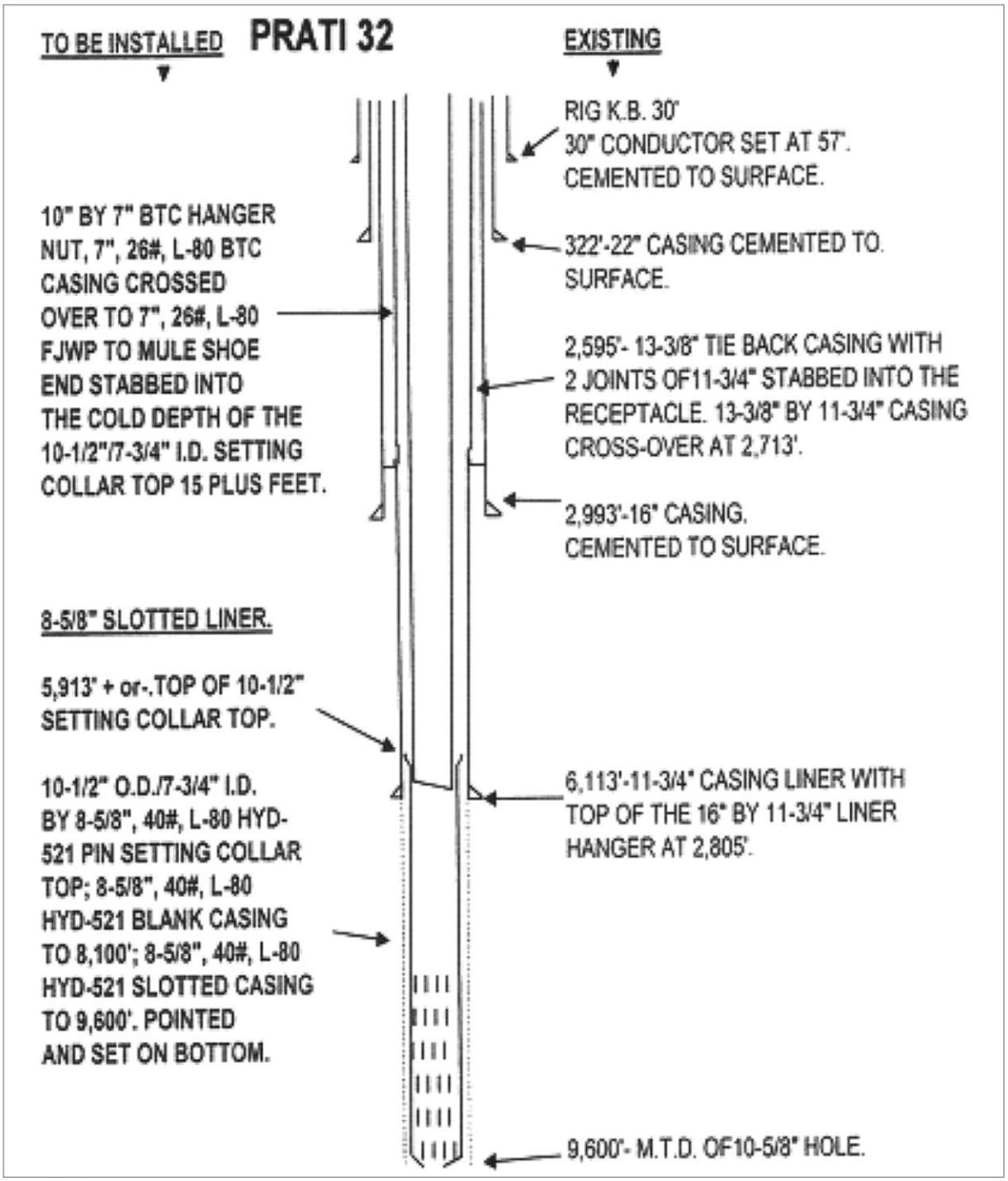
Figure 2.4-3: PS-31 Completion Diagram



SOURCE: Calpine

Figure 2.4-4: P-32 Completion Diagram



SOURCE: Calpine

Figure 2.4-5: Photograph of a Typical Drill Rig

SOURCE: Calpine 2010

Sumpless Drilling - A sumpless drilling mud system is proposed for the project. During the drilling process, a liquid holding tank would be used for fresh water and a solids holding tank would be used for solids brought to the surface by the circulation of drilling mud. Using the primary tanks, solids separation system/centrifuge process and transfer pumps, drilling mud, and water would be continuously circulated and returned down the well hole in a closed loop system.

The entire tank and solids removal system would be enclosed within a berm, as would the rig substructure and auxiliary equipment. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit. Mud or aerated mud is proposed for initial drilling operations.

H_2S Abatement - The well is expected to produce 4.0 percent to 7.5 percent NCG by weight, and about 1000 to 1800 parts per million (ppm) of hydrogen sulfide (H_2S) while drilling. H_2S abatement would be required to meet Air Pollution Control District and the US Environmental Protection Agency's (EPA) regulations. Calpine has obtained an Authority to Construct

(ATC)/temporary Permit to Operate (PTO) for the reopening of PS-31 (Appendix D). A similar permit would be obtained for P-32. All permit requirements would be met for H_2S emissions rates.

Emissions of H_2S gas would occur during the air drilling phase of well construction and during well testing. Hydrogen sulfide is a natural component of the produced geothermal steam, and effective techniques for abating H_2S emissions during geothermal well drilling and testing activities have evolved in the Geysers. A Northern Sonoma County Air Pollution Control District (NSCAPCD) approved chemical abatement system would be used to control H_2S emissions during well construction and testing.

The abatement method that would be used during air drilling would be either a scrub and inject or scrub and oxidize method, depending on whether an injection well is available to directly return the steam condensed solution of hydrogen sulfide and sulfide ions back into the geothermal reservoir. Scrubbing is the process of removing a chemical from a vapor. The abatement process would consist of injecting a metered stoichiometric[1] amount of aqueous sodium hydroxide (caustic, NaOH) into the blooie[2] line to scrub the H_2S from the steam into a solution as hydrosulfide and sulfide ions. The resulting solution would either be directly injected into the reservoir or a metered injection of stoichiometric amounts of hydrogen peroxide (H_2O_2) would be added into the blooie line as needed to oxidize the hydrosulfide and sulfide ions to sodium sulfate (Na_2SO_4), which would not revert back to hydrogen sulfide.

The air drilling abatement equipment consists of a 12 to 14-foot diameter cyclone separator/muffler connected at the end of the blooie line, 2 to 4 chemical metering pumps, treatment chemicals storage totes, a water storage tank, emergency shower and eyewash facilities, and miscellaneous hoses and fittings. The cyclone separator serves to separate condensate, rock cutting solids, and any sulfur solids that form in the abatement of steam. Abated steam is exhausted to the atmosphere. Condensate, rock cutting solids, and any sulfur solids are collected in a tank. Solids and particulate matter settle and are transported off-site to Calpine's permitted waste management unit in The Geysers. Condensate is recycled/recirculated in the blooie line for reuse in scrubbing H_2S and particulate in the blooie line.

For well testing, H_2S entrained in the steam produced during tests would be chemically treated and abated in the same manner as during the air drilling phase of well construction.

Blowout Prevention Equipment (BOPE) - BOPE would be used on each well drilled. All necessary precautions would be taken to maintain control of the wells at all times to prevent the uncontrolled release of geothermal fluid into the environment. The BOPE would conform to California Department of Oil, Gas, and Geothermal Resources (CDOGGR) specifications and requirements and would be described in the Notice of Intent to drill the respective wells submitted to CDOGGR.

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[1] Stoichiometry is the calculation of quantitative (measurable) relationships of the reactants and products in a balanced chemical reaction.

[2] A blooie line is a large diameter pipe that routes returning air and drill cuttings to a separator and muffler. The line may be equipped with high-pressure nozzles that spray water to settle dust and sodium hydroxide and hydrogen peroxide to eliminate hydrogen sulfide odors.

The existing Calpine Geysers Emergency Preparedness and Response Plan also includes a Well Blowout section that provides emergency contingency procedures to be taken by employees in the unlikely event of the loss of control of a well, or a well blowout. The Plan sets forth steps to be taken to safely secure the site, assure the safety of on-site personnel and the public, implement emergency notifications, minimize environmental damage, and regain control of the well.

Well Completion

An unstable mélange zone near 7,000 feet measured depth is known to have caused well bore bridging in several of the wells in the proposed EGS area. A "bridge" is an obstruction in the uncased well bore caused by a section of collapsed rock. Bridges occur in the uncased or unlined portions of wells when unstable formation (e.g., mélange) sloughs into the well bore and blocks the flow of fluid. A drill bit would be run through the open hole wellbores to clean-out bridges to their total depth.

The Prati State-31 well would then be deepened, if necessary, 500 feet into the HTZ to ensure a sufficient depth of the well for the demonstration.

An 8-5/8 inch combination blank/perforated liner would be installed to total depth, topped with stab-in receptacle inside 11¾ inches. Blank liner would be installed through the normal temperature reservoir and perforated liners would be installed through the HTZ. Blank liners do not let fluid pass into or out of the well, while perforated liners allow for exchange.

A blank 7 inch hang down casing would be installed from the surface into the stab-in receptacle. The well head would be prepared for injection tie-in and shut-in, and then the rig would be released. Well completion diagrams are shown in Figures 2.4-4 and 2.4-5.

Some issues could arise during drilling into the mélange zones and argillite zones below 7,000 feet mean depth; these zones would need to be cleaned out. While drilling through these weak formations below steam entries, three or more air compressors, delivering about 3,600 cubic feet per minute, would be required. This volume of air was found necessary while drilling the original wells to prevent fill on connections and getting stuck.

"Killing" the steam flow from the well prior to running the 8-5/8 inch liner may cause bridging below a 7,000 foot depth in mélange and argillite units. It would be necessary to run a "hot" injection liner into the well while steam is flowing from the well. The liner would be capped on the bottom with a cement plug in order to prevent flow through the liner while running it. Subsequently, the liner would be perforated in the HTZ section.

Well Logging and Testing

Logging and injection testing would occur after the drill rig is moved off-site. Prior to injection, the well would be extensively tested and logged to determine the characteristics of both the overlying normal temperature (450 ^{0}F) reservoir and the underlying HTZ (>500 ^{0}F). The logging and testing would include steam temperature, pressure, and flow rates; location of steam entries and downhole geochemical sampling; and sampling of the condensate from the steam delivered to the surface.

Numerous temperature and pressure logs would be run during the stimulation phase of the demonstration at the different injection rates to determine the height of the water column in the well bore. No nuclear data logging devices would be used. Logging would enable monitoring of down-hole pressure changes in the well on a regular basis and computation of any long-term changes in well injectivity. Downhole pressure data would also be used to adjust the injection rate so that water levels in the injection well remains below the top of the HTZ. Pressure falloff data recorded during any planned or unplanned interruptions in injection may be interpreted to obtain any temporal changes in formation properties such as transmissivity in the vicinity of the injection wells.

The fluid produced from the well is passed through various-sized orifice plates, which cause differential pressures that are used to determine the mass flow rate and corresponding flowing pressure. Another reservoir test measures static pressure when fluid flow has ceased. Geochemical samples of the vapor and condensed liquid components are measured during the flow tests.

No liquid waste would be generated. It is anticipated that all flow tested medium would be superheated steam and would evaporate from the well head.

Staging, Personnel, and Schedule

All vehicle traffic associated with the project would be restricted to existing access roads that would be maintained. All personnel, subcontractors, and service personnel would attend a training meeting that would include education on the environmental rules and regulations pursuant to all relevant operating permits. Speed limits of 15 miles per hour (mph) would be observed on all dirt roads in the project area in order to meet Calpine safety requirements and minimize dust, avoid collisions, and avoid incidental death of native fauna. Water trucks would be used during access road construction, well pad construction, and drilling operations to minimize dust emissions.

Staging would occur on the well pad. An estimated 12 to 15 crew members would be involved in the drilling activities. Re-opening and completion would take approximately one month, assuming the re-opening and re-completion go as planned. Flow testing would take several days until flow rates have stabilized. Only one well would be drilled and tested at a time.

Water Supply

Approximately 20,000 gallons of water per day (~14 gallons per minute (gpm)) would be needed for re-drilling. Water would be sourced from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP.

Water wells may be drilled for well pad dewatering to prevent steam quenching and well bore corrosion.

Potable water would be delivered to the site for consumption purposes during construction and well drilling operations.

Waste Disposal

A tank system would be used on each production well pad for the containment and temporary storage of drill cuttings and waste drilling mud. All machinery, drilling platforms, and oil and fuel storage areas on the drill pads would use containment in order to prevent the off-site release of spills from these source areas. When mud drilling is finished, all liquid mud and solids would be collected and hauled by tanker trucks to Calpine's geothermal drilling mud and cuttings disposal area (GDMACDA) Waste Management Unit and the Super Sump Solid Waste Management Facility in The Geysers. The system would allow for sumpless drilling of the geothermal resource, as previously described.

Storm water from areas off of the well pad would be directed to ditches around the well pad to settlement basins and through energy dissipaters into local drainage channels, consistent with storm water best management practices required by the County of Sonoma and California Regional Water Quality Control Board.

Sanitary facilities would be provided and maintained by a licensed local contractor.

Construction of Injection System Equipment

The injection system at the well would be constructed and would consist of a well head valve, double check valves for back flow prevention, a metering control valve, diffuser, flow meter, pressure indication, and other ancillary piping. The control valve would be operated from Calpine's central control room. Any electrical needed for the control system would be supplied via a drop from the existing power lines and would run parallel to the pipeline.

2.4.3 PHASE II: STIMULATION

Overview

Phase II is the phase with potential for environmental effects. This phase includes:

- Performing the stimulation
- Monitoring, evaluating, and assessing the results

Performing Stimulation

Injectivity tests would occur prior to stimulation. The initial flow rate needed to collapse the steam bubble in the well bore so that injected water could flow into the wells under vacuum would involve injecting 1,200 gpm of water from the SRGRP pipeline into each well for 8 hours.

Once the steam bubble in the well bore is collapsed and the well is injecting under vacuum, the injection would likely be carried out initially at a low rate (e.g., 100 gpm). Injection would involve supplying gravity fed water from the SRGRP pipeline into the injection well.

Depending on the ability of the fractures to accept the fluid, the injection rate would then be increased (for example, to 200 gpm and 400 gpm). Geothermal wells often exhibit a nonlinear relationship between injection rate (M) and feed zone pressure (p). The suggested injection program (e.g., injection at 100, 200, 400, and 800 gpm) would be designed to ascertain if the pressure increase would result in the opening up of pre-existing fractures in the HTZ, and whether

the change would be reversible. As PS-31 is being stimulated, P-32 would be monitored continuously.

Stimulation would occur for 6 months per well, with a duration for each injection rate of about 1 month. Tracers would be injected into the stimulated well (ammonia in PS-31 and tritium in P-32) and PTS tests for each injection rate would be performed. Geochemical sampling would also be performed. The stimulated well would be shut after the stimulation phase and pressures would be monitored for the next 6 months, while the other well is being stimulated. One well would be stimulated, monitored and shut-in, and then the second well would be stimulated and monitored. This six month process would repeat for two years. Each well would therefore be stimulated for 2 six month periods and monitored without injection for 2 six month periods.

Data Collection, Assessment, and Evaluation of the Well Bore Properties

Accurately monitoring micro-earthquake (MEQ) activity would be conducted from the start of water injection into the HTZ, in order to learn how the injection response moves through the reservoir over time.

Continuous monitoring would occur during the first two years of the project implementation. The effectiveness of the well bore stimulation would be assessed by:

- Evaluation of changes in injectivity over time
- Running PTS logs during steam production before and after stimulation (to register new flowing fractures along the well bore and increased overall production)

Other well bore logging equipment available to the project may also be tested.

The effectiveness of stimulation to create an EGS would be evaluated by:

- Performing high-precision location of micro-earthquakes (MEQ's) during stimulation (to estimate the volume of the rock mass simulated by shear reactivation of critically stressed fractures)
- Conducing 3-D seismic wave tomography using MEQs during the stimulation to study changes in rock-mass mechanical properties
- Conducting chemical and isotope analysis of production fluids (to investigate chemical signature of the creation of new fracture surfaces)

The project would utilize the expanded seismic network that is being installed under the "Monitoring the Injection of Fluids From the Santa Rosa Pipeline on Seismicity at The Geysers, California Geothermal Field" project, which would be available by the time the proposed project commences. The expanded seismic network would provide the needed coverage to perform high-precision MEQ location and 3-D seismic wave tomography and source mechanism analysis.

The actual injection would be coupled with the reservoir-geomechanical model at two scales: (1) at the well bore scale to simulate changes in injectivity and (2) at the scale of the EGS area to compare with observed patterns and the evolution of induced seismicity. This would confirm whether the stimulation worked as planned. The numerical modeling would then be used to analyze and understand the cause of any unexpected behavior.

2.4.4 PHASE III: LONG TERM INJECTION, DATA COLLECTION, AND MONITORING

Phase 3 would include monitoring of the sustainability of the proposed EGS. Continued injection and monitoring could occur during this phase although the amount of injection is unknown at this time and would depend upon the results of the stimulation. While some of the traditional Hot Dry Rock EGS concept involves one, or a few, repeated hydraulically pressurized stimulations to create an EGS, the proposed project would involve continuous injection, which may result in a continuous expansion of the EGS reservoir over tens of years. An important measure of success would be a sustained steam production rate and decreasing NCG concentrations within the operating area.

The monitoring and modeling techniques and data analysis employed for the first two years would also be applied for the continuous long-term monitoring. The exact extent and frequency would be determined in consultation with the DOE.

2.5 No Action Alternative

Under the No Action Alternative, the DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The existing geothermal extraction in The Geysers would continue as it currently operates. The use of the geothermal resource would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts could occur anyway.

2.6 Safety and Risk Assessment

Appendix F provides a detailed description of Calpine's emergency plans for:

- Injuries
- Well blowouts
- Fire
- Spill or discharge contingencies (for drilling mud, geothermal fluid, lubricants, fuels, etc.)
- Hazardous gas control
- Drilling safety and action plans
- Earthquakes

The purpose of these plans is to provide guidance to field personnel and management in the event of an uncontrolled well flow (e.g., "blowout") or other field related emergency. The plans are intended to be comprehensive in that they describe the nature of various hazards or problems that might be encountered and specify appropriate preventive or anticipatory actions and equipment, as well as specific responses, notifications, and follow up procedures that are required in the event

of such a field emergency. In addition to blowouts, emergencies (e.g., accidents and injuries), fire hazards management, and risk assessment are covered.

2.7 Permitting

Table 2.7-1 lists the permits, reviews, consultation, and approvals required for the proposed project, as well as the status of the permits and/or timing of acquisition.

Table 2.7-1: Permitting Requirements and Status

Agency	Permit/Approval	Status or Timing
DOGGR	Notice of Intent	60 days prior to the re-opening and conversion of exploratory well to injection, a Notice of Intent will be filled with the Santa Rosa office.
Sonoma County	Use Permit 08-0062 Permit	Issued June 12, 2009
Northern Sonoma County Air Pollution Control District (NSCAPCD)	Authority to Construct Permit to Operate	An application must be submitted to re-open and test a well approximately 60 days in advance of drilling. The permit has already been obtained for PS-31, although it may need to be renewed. A permit is needed for P-32.
North Coast Regional Water Quality Control Board (RWQCB)	Waste Discharge Requirement	Issued, Board Order No. R1-2009-0103
State Water Resources Control Board	Notice of Intent (NOI)	An NOI will be submitted prior to grading and construction work for enrollment under the General Construction National Pollutant Discharge Elimination System (NPDES) permit. A Stormwater Pollution Prevention Plan will be prepared and maintained on-site during construction.

2.8 Environmental Protection & Applicant Committed Measures

The specific environmental protection measures listed by activity or environmental resource area below are incorporated into the Calpine's proposed action as integral components of the proposed project. Refer to Appendix G for written confirmation of these environmental commitments.

Air Quality

1. Devegetated areas would be watered or other methods would be employed to entrain dust, in order to minimize any adverse impacts from particulate matter emissions during ground disturbance, including asbestiform minerals.

2. All trucks hauling soils or other dusty materials would be covered and two feet of freeboard would be maintained in the trucks
3. Inactive construction areas would be hydroseeded or covered with non-toxic soil stabilizers. "Inactive" areas are previously graded areas that are inactive for 10 days or more.
4. Traffic would be limited to 15 miles per hour on unpaved roads.
5. Painting of the steam pipelines and supports would conform to NSCAPCD Rule 485 for use of compliant architectural coatings.
6. The Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by the California Air Resources Board (CARB) would be implemented to avoid adverse effects associated with the emissions of serpentine/asbestiform minerals.
7. All conditions of the ATC and temporary PTO from the NSCAPCD would be implemented.
8. Dust emissions from venting steam would be reduced by injecting water into the blooie line
9. H_2S control would be accomplished through the installation of a NSCAPCD approved chemical abatement system
10. Calpine will implement all measures required in the Authority to Construct and Permit to Operate permits issued by the NSCAPCD (included in Appendix D of this EA).
11. Calpine will notify the NSCAPCD 24 hours prior to initiating any planned venting operations until such time that an emissions release protocol governing emissions and notifications for such operations is prepared and provided to the NSCDAPCD

Geology

1. The SRGRP pipeline spur would be constructed using Standard Engineering Methods for Expansive Soils, as necessary.
2. Calpine will comply with the DOE's"Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" (Majer et al. 2008).
3. The stanchions for the SRGRP pipeline will be constructed using Standard Engineering Methods for Expansive soils, as necessary.

Biological Resources

1. In order to protect yellow warblers and Common Yellowthroats, any work proposed within riparian woodland habitat between April 1 and August 31 would be surveyed by a qualified biologist. If a nest of either species is discovered within 200 feet of proposed construction activities, construction

would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.

2. In order to protect sharp-shinned hawks, any work proposed within riparian woodland series such as white alder or cattails series, between April 1 and August 31 would be surveyed by a qualified biologist. If an active nest is found within 500 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.
3. If construction or re-drilling is to occur between April 1 and August 31 pre-construction surveys would be performed in all construction areas and the drilling area within 500 feet of suitable habitat for raptors. If active nests are found, work within these areas would be halted until after August 31 or a qualified biologist has determined the nest is no longer active and the young have fledged.
4. No trees would be removed during construction of the SRGRP pipeline.

Water Resources

1. Erosion control methods and Best Management Practices (BMPs) in accordance with a Stormwater Pollution Prevention Plan (SWPPP) would be utilized (such as certified weed-free straw waddle) to reduce erosion or siltation on or off-site during grading of the well pad and construction of the SRGRP pipeline spur.
2. No water would be released to the surface from the pipeline during testing or operation of the pipeline.
3. A SWPPP would be developed and a Notice of Intent submitted to the California State Water Resources Control Board, prior to grading or construction activities.
4. A Spill Prevention, Control, and Countermeasure Plan (SPCC) would be maintained on-site and implemented to contain incidental drips and/or spills. The plan will identify equipment and procedures used for containment and recovery of accidental spills
5. Contamination during construction along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater.
6. Containment berms will be constructed around all hazardous material or potentially hazardous material storage for both construction and operation.
7. A drainage system will be installed around the well pad to contain stormwater.
8. BOPE will be installed to minimize blowouts or contamination of the localized shallow aquifer as required by CDOGGR regulations.
9. Calpine will obtain an updated Waste Discharge Order that will address injection of effluent and condensate into the EGS wells. Calpine will submit

injection reports to CDOGGR. Injection of water and disposal of waste discharge due to drilling will comply with all requirements outlined in the permit

Cultural Resources

1. A condition from the Wildhorse Development Project has been incorporated into the proposed action to further protect cultural resources. The condition requires placing the following note on all construction plans and providing the language to all contractors and superintendents on the job site:

   "Should any previously unknown historic or prehistoric resources, including but not limited to charcoal, obsidian or chert flakes, grinding bowls, shell fragments, bone, pockets of dark, friable soils, glass, metal, ceramics, wood or similar debris, be discovered during grading, trenching or other on-site excavation, earthwork in the vicinity of the find shall cease, and the County of Sonoma Permit and Resource Management Department (PRMD) staff shall be notified so that the find can be evaluated by a qualified archaeologist (i.e., an archaeologist registered with the Society of Professional Archaeologists). When contacted, a member of PRMD Project Review staff and the archaeologist shall visit the site to determine the extent of the resources and to develop proper mitigation measures required for the discovery. No earthwork in the vicinity of the find shall commence until a mitigation plan is approved and completed subject to the review and approval of the archaeologist and Project Review staff"
2. A qualified archaeological monitor will be present during pipeline construction along all of West Squaw Creek Road to the tie-in location to ensure that no construction activities occur outside of the existing disturbed road shoulder and to monitor for cultural materials during construction. If a resource is found during construction, the monitor shall have the authority to stop construction until it can be further evaluated. The pipeline would be installed above-ground on stanchions, such that ground disturbance is already minimized to only the stanchion foundations. Any resource found would be avoided by spanning over the resource and/or moving the pipeline to avoid any resource.

Noise

1. Calpine would adopt the following measures to minimize noise from the drill rig during re-drilling and testing operations:
   - Shielding of drill rig motor and air compressors: When practicable, set up the drill rig so that it acts as a barrier to shield noise from the motor and compressors from receptors.
   - Buffer metallic surfaces: If needed, cover V-door and drill rig floor with rubber or wood to reduce impact noise from pipes against these metal surfaces.

- Enclose Rig Floor: If needed, enclose rig floor with metal panels including the V-door opening.
- Muffle connection equipment: Install mufflers around pipe connection equipment such as air tuggers and winches.
- Install check valve: Install a check valve in the drill string to slowly bleed off air pressure and reduce high pressure release noise.
- Bleed air pressure through cyclone muffler: Reduce pressure release noise by bleeding air pressure through the blooie line rather than the
rig floor.
- Pipe Handling: Implement procedures for handling drill pipe that minimize contact with metal surfaces (i.e., on the V-door and catwalk).
- During air drilling, the rig will be outfitted with a blooie line and cyclonic separator/muffler designed to reduce noise from the release of steam. Similarly, during well testing a portable blooie line and muffler will be utilized to reduce steam release noise.
- Rig Crew training: Train all rig crews in noise awareness.

2. Noise would be controlled in accordance with the standards set in the Noise Element of the Sonoma County General Plan.
3. If noise complaint investigations indicate the appropriate noise standard levels have been or may be exceeded, Calpine would be required to install, at their expense, additional professionally designed noise control measure(s).
4. Well pad, road, and pipeline construction/grading activities would not occur during the nighttime.

Visual Resources

1. Pipelines would be painted in earth-tone colors.
2. Rig lights and any other temporary lighting would be shaded and focused downwards to reduce nighttime glare from the well pads during drilling operations. Temporary lighting would only be on for short periods of time, as necessary.

Hazardous Materials, Waste Handling, Human Health and Safety, and Risk Management

3. Fire hazards would be minimized through the maintenance of an on-site water supply that can be used to put out any potential fires. Other measures to reduce fire hazards would be implemented and include:
    a. Fire extinguishers and shovels would be available on-site.

   b. All brush build-up around mufflers, radiators, and other engine parts must be avoided; periodic checks must be conducted to prevent this build-up.
   c. Smoking would only be allowed in designated smoking areas; all cigarette butts would be placed in appropriate containers and not thrown on the ground or out windows of vehicles.
   d. Cooking, campfires, or fires of any kind would not be allowed.
   e. Portable generators used in the Project Area would be required to have spark arresters.

4. Existing Calpine health and safety procedures provide plans that address prevention of fires in The Geysers. These plans would be implemented, including:
   - Fire Prevention Plan (HSP-60)
   - Hot Work Permit Procedure (No. 145)
   - The Calpine Geysers Emergency Preparedness and Response Plan
5. Calpine would remove and clear away dry, combustible vegetation from construction sites in the project area that contains substantial forest fire risks and hazards, or are very high fire hazard severity zones as defined by California Division of Forestry and Fire Protection. Grass and other vegetation less than 18 inches in height above the ground may be maintained where necessary to stabilize the soil and prevent erosion. Vehicles would not park in areas where exhaust systems contact combustible materials. Fire extinguishers would be available on the construction site when working in high fire hazard areas to assist in quickly extinguishing any small fires. The Construction Manager would have on site the phone number for the local fire department(s) and would have a phone available when working in high fire hazard areas should additional fire fighting capabilities be required.
6. Calpine would implement the Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by CARB.
7. Workers would wear hearing protection and other personal protection equipment (PPE) as required by the Occupational Health and Safety Organization (OSHA) to prevent injuries.
8. Construction workers would comply with OSHA and CalOSHA asbestos removal worker requirements whenever serpentine rock containing over one percent asbestos is being excavated.
9. Calpine would implement its blowout prevention plan.
10. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit.

3: Affected Environment and Environmental Consequences

3.1 Environmental Categories Evaluated and Dismissed from Further Analysis

3.1.1 OVERVIEW

The DOE NEPA guidance documents and a public scoping period were used to identify environmental categories within the affected environment and to evaluate the potential for impacts from the proposed action. Elements of the affected environment are discussed in detail. Some environmental impact categories are not present at the project site or are not likely to have impacts associated with the proposed action. Table 3.1-1 provides an overview of which environmental categories are evaluated or dismissed.

Several environmental analyses have been performed for geothermal development in the project area and are incorporated into this EA by reference. Two key projects include the Subsequent Initial Study and Mitigated Negative Declaration (IS/MND) for the Wildhorse Development Project and the Incremental Recycled Water Program (IRWP) EIR for the City of Santa Rosa.

This project falls within a larger program known as the Wildhorse Development Project. Under the Wildhorse Development Project, Calpine is proposing to drill up to 58 geothermal wells, up to 14 existing drill pads and construct up to 29,000 feet of access corridors for steam pipelines, roads, associated electrical distribution (21kilovolt lines), and other appurtenant facilities to connect the production and injection wells to existing geothermal infrastructure and power plant units. The Wildhorse Development Project was subject to review under the CEQA, as several local and state permits were required for the project.

The IRWP addressed the environmental effects of construction of the pipeline to the project area and the transport and injection of tertiary treated recycled water into the Geysers geothermal reservoir. The analysis and mitigation is incorporated herein by reference.

3.1.2 RESOURCES DISMISSED FROM FURTHER ANALYSIS

Geology and Soils

Mineral Resources

The Sonoma County General Plan does not designate the project area as within a known mineral resource deposit recovery site (Sonoma County 1989). There are no known mineral resources or geologic resources of commercial value in the project area, other than the geothermal resource, which is addressed in Section 3.3 Geology. Mineral Resources is dismissed from further evaluation.

Table 3.1-1: Environmental Categories Evaluated or Dismissed

EA Resource	Impact Categories	Determination
Air Resources	Air Quality	Addressed in EA.
Geology	Soils	Addressed in EA
	Mineral Resources	No adverse impacts expected. Dismissed from further analysis.
	Seismicity	Addressed in EA.
	Geothermal Resource, Natural Resources and Energy Supply	Addressed in EA.
Biological Resources	Vegetation and Wildlife	Addressed in EA.
	Wetlands	Addressed in EA
	Rare and Endangered Species	Addressed in EA.
Water Resources	Floodplains	No adverse impacts expected. Dismissed from further analysis.
	Water Quality	Addressed in EA.
	Groundwater Resources	Addressed in EA.
Cultural Resources	Historical, Architectural, Archaeological, and Cultural Resources	Addressed in EA.
Land Use	Land Usage	No adverse impacts expected. Dismissed from further analysis.
	Farmlands	No adverse impacts expected. Dismissed from further analysis.
	Transportation	No adverse impacts expected. Dismissed from further analysis.
Noise	Noise	Addressed in EA.
Infrastructure	Infrastructure	No adverse impacts expected. Dismissed from further analysis.
Visual Resources	Light Emissions	Addressed in EA.
	Visual Impacts	Addressed in EA.
	Wild and Scenic Rivers	None present. Dismissed from further analysis.
Socioeconomics	Socioeconomics	No adverse impacts expected. Dismissed from further analysis.
Environmental Justice	Environmental Justice	No adverse impacts expected. Dismissed from further analysis.
Hazardous Materials and Human Health and Safety	Hazardous Materials, Pollution Prevention, and Solid Waste	Addressed in EA.
	Health and Safety	Addressed in EA.

SOURCE: US DOE NEPA Guidance Document and Consultant Evaluation

Water Resources

Floodplains

The project would involve the installation of a pipeline on stanchions; however, the pipeline would be installed entirely along the shoulder of an existing road. The project area is over 4.5 miles away from the nearest 100-year floodplain as defined by the Federal Emergency Management Agency (FEMA) (FEMA 1996). Adverse impacts are not expected and Floodplains is dismissed as an impact category for analysis.

Land Use

Land Usage

The project would not conflict with any of the permitted land uses or require a change in land use within the project area. Land in the project area is zoned for resources and rural development (Sonoma County 2008a). Impacts are not expected and Land Usage is dismissed as an impact category for further analysis.

Farmlands

The project would not affect agricultural lands or prime or unique farmland soils as defined by the Natural Resource Conservation Service (NRCS). The project would not occur on or near any farmlands. Impacts are not expected and Farmland is dismissed as an impact category for analysis.

Transportation

The project would not result in an increase in vehicular traffic or require a change in traffic circulation. Small increases in traffic on public roads could occur from Phase II activities (re-grading the well pad and re-drilling), but impacts would not be adverse because the area is remote and these types of operations are common in the area. No new roads would be required. Transportation is dismissed as an impact category for analysis.

Infrastructure

The project would not require infrastructure other than access to the well pad via existing access roads and construction and use of the SRGRP pipeline for injection water. The well pads are accessible via Seven Mile Road and Squaw Creek Road, which are currently graded and maintained with road base. Permanent power for the well pad would be needed for equipment operation on the well pad and would be supplied by generators. Water use, wastewater use, and landfill use are addressed in the EA in Sections 3.5 Water Resources and 3.9 Hazardous Materials and Human Health and Safety. Infrastructure is otherwise dismissed as an impact category for analysis.

Visual Resources

Wild and Scenic Rivers

There are no national or state Wild and Scenic Rivers within the project area; therefore, impacts are not expected and Wild and Scenic Rivers is dismissed as an impact category for analysis.

Socioeconomics

There are no residents near the project area. The closest residents are located 2 miles from the well pad site. The proposed site is an existing well pad within the larger geothermal well field operated by Calpine. Construction and operation of the proposed project would not result in any major adverse socioeconomic changes. Socioeconomics is dismissed as an impact category for analysis.

Environmental Justice

There is no population in the vicinity of the proposed project. The project requires limited construction and drilling activities that are commonplace in the project region. The project could result in some air emissions; however, these effects would be mitigated. The project would not have an adverse effect on any minority or low income populations pursuant to Executive Order 12898; therefore it is dismissed as an impact category for analysis.

Intentional Destructive Acts

In December 2006, the DOE Office of General Counsel issued interim guidance stipulating that NEPA documents completed for DOE actions and projects should explicitly consider intentional destructive acts (i.e., acts of sabotage or terrorism). Construction and operation of the proposed project would not involve the transportation, storage, or use of radioactive, explosive, or toxic materials. Consequently, it is highly unlikely that construction or operation of the project would be viewed as a potential target by saboteurs or terrorists. The project location is not near any national defense infrastructure or in the immediate vicinity of a major inland port, container terminal, freight trains, or nuclear power plants. The proposed project would not offer any targets of opportunity for terrorists or saboteurs to inflict adverse impacts to human life, health, or safety; therefore it is dismissed as an impact category for analysis.

3.1.3 RESOURCES EVALUATED IN THIS EA

This EA evaluates the impacts of the Proposed Action and the No Action alternative under the following categories:

- Air Resources
- Geology
  - Soils
  - Seismicity
  - Geothermal Resource, Natural Resources and Energy Supply
- Biological Resources
  - Vegetation and Wildlife
  - Wetlands
  - Rare and Endangered Species
- Water Resources
  - Water Quality
  - Groundwater Resources
- Noise

  - Visual Resources
  - Visual Impacts
  - Light Emissions
- Hazardous Materials, Human Health and Safety, and Risk Assessment
  - Hazardous Materials
  - Health and Safety

3.2 Air Resources

3.2.1 AFFECTED ENVIRONMENT

Climate

The climate within Sonoma County (County) is complex due to the presence of mountain ranges and valleys with various climate regimes. The predominant wind direction is from the south and southeast.

The average seasonal precipitation in Sonoma County ranges from less than 20 inches in the extreme southeast corner of the County through 30 and 40 inches over much of the central part of the County. In the mountains of the northwest portion of the County, rain totals increase to more than 70 inches at some points, and in the northeast they increase to more than 80 inches (Sonoma County 2008a).

The Coast Range east of the Russian River, provides a barrier that protects Sonoma County from the very hot weather of the central valley of California during summer month. Low elevations within the County receive enough sunshine during the summer without any import of hot air from the interior. The nearby Pacific Ocean provides a source of cool, moist air during the summer, and the steady inflow of marine air holds temperatures at low levels over that part of the County through which it moves (Sonoma County 2008a).

Air Quality Regulatory Setting

Air quality in California is regulated by CARB, which implements local programs as well as operates the federal environmental program within the state for implementation of the Federal Clean Air Act, as delegated by the US EPA. The air pollutants of greatest concern in California are:

- Ground-level ozone, commonly known as smog
- Fine particulate matter (mostly from wood smoke or other combustion sources, cars and dust) known as
  - Particulate matter 10 microns and smaller in diameter (PM_{10}) and
  - Particulate matter 2.5 microns and smaller in diameter ($PM_{2.5}$)
- Hazardous air pollutants (also called Air Toxics)
- Carbon monoxide (mostly from motor vehicles)

Two California air basins[1] are located within Sonoma County: North Coast and San Francisco Bay. The project area is located entirely within the North Coast Air Basin. The project area lies within the NSCAPCD. The NSCAPCD is the local permitting agency responsible for the implementation of federal and state air quality plans in addition to preparing regional air quality plans.

The NSCAPCD is classified as having attained all federal air standards; however, the entire North Coast Air Basin is currently designated as in non-attainment for the state 24-hour and annual average PM_{10} standards. The air basin is designated as unclassified for the state annual $PM_{2.5}$ standard because available data is insufficient to support a designation of attainment or non-attainment (EPA 2009a).

Federal and state standards for ambient pollutant concentration levels are included in Table. 3.2-1. Table 3.2-2 lists the emission standards that apply to direct sources of pollutants. Projects with emission sources may be required to obtain an ATC and PTO from the NSCAPCD.

Table 3.2-1: State and Federal Air Quality Standards

Pollutant	Average Time	California Standards	Federal Standards
Ozone	1-Hr. 8-Hr.	0.09 ppm 0.070 ppm	-- 0.075 ppm
Carbon Monoxide	1-Hr. 8-Hr.	20.0 ppm 9.0 ppm	35.0 ppm 9.0 ppm
Nitrogen Dioxide	Annual 1-Hr.	0.030 ppm 0.18 ppm	0.053 ppm –
Sulfur Dioxide	Annual 24-Hr. 1-Hr	– 0.04 ppm 0.25 ppm	0.03 ppm 0.14 ppm –
PM_{10} $PM_{2.5}$	Annual 24-Hr. Annual 24-Hr.	20.0 μg/m³ 50.0 μg/m³ 12 μg/m³ –	 150.0 μg /m³ 15.0 μg/m³ 35 μg/m³
Lead	30-day Calendar Quarter	1.5 μg/m³ –	– 1.5 μg/m³

Note:
ppm = parts per million
μg/m³ = micrograms per cubic meter
N/A = Not available

[1] An air basin is a geographical structure or climatic condition that results in relatively little movement of air in or out of the area.

Table 3.2-2: Significant Emission Rates for Pollutants Regulated Under the Clean Air Act

Significant Pollutant	Emission Rate (tons/year)
Carbon Monoxide	100 tons/year
Nitrogen Oxides	40 tons/year
Particulate Matter	25 tons/year
PM_{10}	15 tons/year
Sulfur Dioxide	40 tons/year
Volatile Organic Compounds	40 tons/year
Lead	0.6 ton/year
Fluorides	3 tons/year
Sulfuric Acid Mist	7 tons/year
Hydrogen Sulfide	10 tons/year
Total Reduced Sulfide	10 tons/year

SOURCE: EPA 2009b

Air Quality in Sonoma County

Inland areas with higher elevations in the western portions of Sonoma County receive less fog and less influence from warm, moist coastal summers. The northern portion of Sonoma County is mostly rural and hilly and includes two urban areas: Healdsburg and Cloverdale. Natural sources such as wind-blown dust, pollen, and intermittent forest fires can occasionally contribute to local levels of pollutants in the atmosphere. Forest fires emit air pollutants such as nitrogen oxides, particulates, and unburned organic compounds. Together with natural sources, human activities can contribute to occasional locally elevated air pollution levels in northern Sonoma County.

The NSCAPCD has adopted regulations to improve air quality with the implementation of regulations requiring all wood burning devices to meet prescribed standards and by prohibiting the installation of conventional fireplaces in new construction or remodeled houses. Construction projects within the district are regulated by public nuisance provisions set forth by the NSCAPCD. Rules 410 and 430 are two applicable provisions which regulate the visible emissions and fugitive dust emissions, respectively (Sonoma County 2008a). Rule 410 sets standards on the length of time and opacity of visible air contaminant emissions. Rule 430 requires reasonable precautions be taken to prevent particulate matter from becoming airborne.

Calpine obtained an ATC and temporary PTO from the NSCAPCD for well PS-31on September 21, 2009. The permit regulates emissions from re-drilling and flow testing. The permit is included in Appendix D. A similar permit would be obtained for well P-32. All permit conditions would be implemented.

Greenhouse Gases and Global Warming

GHGs are global pollutants, unlike criteria air pollutants and toxic air contaminants, which are pollutants of regional and local concern, respectively. The most prominent GHGs that have been identified as contributing to global warming are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of GHGs contributing to global climate change are attributable largely to human activities associated with the industrial/ manufacturing, utility, residential, and agricultural sectors. Transportation is also a large contributor of GHGs, particularly CO_2.

3.2.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Fugitive Dust Emissions

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. The primary pollutant of concern during construction activities for the proposed action would be emissions of particulates in the form of fugitive dust. Fugitive dust emissions would be generated by ground-disturbing activities related to transport of workers and equipment to the site, well pad preparation, and construction of the SRGRP pipeline spur for injection water.

Air quality impacts from construction activities for the well pad and SRGRP pipeline spur would be localized and temporary. The existing 2-acre well pad would require approximately one day of re-grading. Well pad preparation would require the clearing of any vegetation that has established; the installation of drainage improvements; and the laying down of gravel. Construction of the 1-mile long SRGRP pipeline spur would require the removal of soils and vegetation that has established itself in the road shoulder. Fill material may be required for stanchions and would include sand and gravel in addition to the removed soils.

Particulate concentrations in the vicinity of the project would increase on a short-term basis (construction and drilling is estimated to last up to 2 months). Fugitive dust emissions from the well pad and construction of the pipeline would be controlled to meet the requirements of Rule 430 and 410(a). Protective measures included in the project description include:

- Watering and/or otherwise entraining dust on devegetated areas to minimize any adverse impacts from particulate matter emissions during ground disturbance
- Covering all trucks hauling soils or other dusty materials and maintain at least two feet of freeboard on the trucks
- Hydroseeding or applying non-toxic soil stabilizers to inactive construction areas (previously graded areas that are inactive for 10 days or more)
- Limiting traffic to 15 miles per hour on unpaved roads

Emissions of particulate matter would not be adverse with implementation of these measures.

Combustion Emissions

Diesel combustion emissions would be emitted from construction equipment and vehicles used to access the project site. Combustion emissions of criteria pollutants and air toxics (small quantities of diesel PM, acetaldehyde, benzene, and formaldehyde) would be released by diesel-powered equipment during road grading, well pad preparation, and the SRGRP pipeline construction. Given the small size of the construction areas, and the small fleet of vehicles needed for construction (less than 5 for 5-8 workers), emissions would be minimal and would not significantly contribute to or exceed air quality standards.

Other Air Emissions

Field application of paint to pipelines and supports may be a source of volatile organic compounds (VOCs). Painting of the steam pipelines and supports would conform to NSCAPCD Rule 485 for use of compliant architectural coatings such that no adverse effects would occur.

Well Bore Modifications

Fugitive Dust Emissions

The proposed project includes modification and re-drilling of two existing wells. The re-opening and modification of both wells would take approximately 30 days; however, only one well would be drilled at a time. The drill rig would be powered by a large bore diesel engine.

The air drilling phase of well bore modifications would be a source of particulate matter. This particulate matter originates from well bore cuttings removed with the compressed air and steam. Well testing would also be a source of particulate matter originating from the well with the steam. Well drilling would produce condensate, rock and sulfur solids, and particulate matter that would collect in a tank. Dust emissions from venting steam would be reduced by injecting water into the blooie line.

Serpentine rock containing asbestos may be encountered during well drilling. The Asbestos Air Toxic Control Measure for construction, grading, quarrying, and surface mining as approved by CARB would be implemented to avoid adverse effects associated with the emissions of serpentine/asbestiform minerals.

Combustion Emissions

Table 3.2-3 shows a worst-case emissions scenario for a large bore stationary diesel engine based on estimated maximum daily fuel consumption at the well pad. Because of the variables in operating parameters of the engines, emissions are expected to be significantly lower than the worst-case scenario. Additional generators and pumps may be required for the project, but these small sources would have a negligible impact on emissions. The emissions from diesel generation would be considerably less than standards (as shown in Table 3.2-2), especially since most impacts would only occur for 1 month per well during drilling modifications. Combustion emissions would not be adverse.

Other Air Emissions

Production of geothermal fluid during well testing would result in release of water vapor (steam) and NCG to the atmosphere. The amount and ratio of the non-condensable gas constituents within

Table 3.2-3: Estimated Emissions from Large Bore Diesel Engines[1]

Air Pollutant	Emission Factor (lbs/mmBTU)	Maximum Estimated Emissions		
		Hourly (lbs/hr)	24-hour (lbs/day)	1-month of Drilling Total Emissions (tons)[2]
Carbon Monoxide (CO)	0.085	4.83	115.92	1.74
Carbon Dioxide (CO_2)	165.00	942.08	22,609.92	339.15
Total Organic Compounds (as Methane (CH_4))	0.09	0.51	12.24	0.02
Oxides of Nitrogen (NO_x)	3.20	18.27	438.48	6.58
Particulate Matter ≤10 microns (PM_{10})	0.0573	0.33	7.92	0.12
Oxides of Sulfur (as Sulfur Dioxide (SO_2))	0.0202	0.12	28.80	0.43

Notes:

[1]Values based on the assumption that a maximum of 1,000 gallons of low sulfur (0.02%) diesel oil fuel will be used, and that the average heating value of the fuel is 19,300 BTU per pound of fuel with a density of 7.1 pounds per gallon.

[2]Assumes 24 hours per day, 7 days per week per well. Drilling would be performed for 1 month per well. Only one well would be drilled at a time. Double the emissions in the last column for 2 month drilling.

SOURCE: EPA 1996

the geothermal fluid are variable among geothermal resource areas and can be substantially different among individual wells within the same geothermal project area. NCG content is typically comprised of primarily CO_2 (usually accounting for about 95 to 98 percent of the total NCG content), with smaller amounts of CH_4, H_2S, and trace amounts of ammonia (NH_3). Trace amounts of elements such as arsenic (As), mercury (Hg) and boron (B) may be present.

The majority of geothermal steam emissions would occur during well drilling, testing, and logging.

Boron, Arsenic, and Mercury Emissions

Steam dispersed into the air may contain boron or arsenic. Table 3.2-4 lists chemical data for boron, mercury, and arsenic gathered from flow tests when the wells were constructed in 1984 and 1985. The wells were never produced before being abandoned in 2000; therefore, no other data was collected on these wells.

Boron, mercury, and arsenic in steam emissions would disperse by wind away from the well pad and would eventually settle onto the ground. The estimated emissions for boron, arsenic, and mercury during a 30 day drilling period are shown in Table 3.2-5. Calculations are shown in Appendix I. Boron is highly soluble in water. As water is injected into the blooie line, a substantial amount of boron is expected to be scrubbed from the steam before it is emitted. The boron

Table 3.2-4: Chemical Data from Flow Tests (1984- 1985) for PS-31 and P-32

	Chloride parts per million by weight (ppmw)	Boron (B) ppmw	Mercury (Hg) parts per billion by weight (ppbw)	Arsenic (As) ppmw
Prati State-31				
N Samples	20	20	20	20
Median	18	70	2	<0.01
Average	25	65	4	<0.01
Prati- 32				
N Samples	22	22	22	22
Median	85	80	3	<0.01
Average	**88**	**73**	**4**	**<0.01**

SOURCE: Calpine 2010

Table 3.2-5: Estimated Emissions of Boron, Arsenic, and Mercury during Drilling and Testing

	PS-31	P-32	Total
Boron	2,520 lb	3,514 lb	6,034 lb
Arsenic	<0.36 lb	<0.44 lb	<1.0 lb
Mercury	0.07 lb	0.13 lb	0.20 lb

SOURCE: Calpine 2010

scrubbing efficiency of the blooie line injection system and cyclone has not been determined, but emissions would likely be less than that presented in Table 3.2-5. Arsenic present in the steam mostly likely becomes soluble in the oxidizing environment of the blooie line and is likely scrubbed from the steam before it is emitted. The amounts of arsenic and mercury that could be emitted in steam over the entire 30 day drilling period is very small (fractions of a pound) and would not have adverse effects. Up to 5,000 pounds of boron could be released; however, boron (as well as mercury and arsenic) is naturally occurring in the area. Adverse effects would not occur.

Hydrogen Sulfide Emissions

Of the non-condensable gas emissions anticipated from the geothermal fluid, the principal constituent of concern is H_2S. H_2S can be released from a well during drilling and would be emitted with the steam and NCGs during flow-testing. H_2S is a colorless, non-condensable gas with a characteristic "rotten egg" odor. H_2S is toxic at certain levels and can cause negative human and animal health effects. Exposure to H_2S can cause dizziness, headache, and nausea at 50 ppm and death from respiratory paralysis at 1,000 ppm. The OSHA indoor workplace standard for H_2S is 10 ppm for an 8-hour day (Klingberg 2005). Nuisance odor is of primary public concern since the

distinctive odor can be easily detected at concentrations far below levels of health concern. Odor is detectable from about 0.008 ppm.

H_2S is typically encountered during the production zone drilling phase. Well PS-31 is expected to produce 4.0 percent to 7.5 percent of non-condensable gases by weight, and approximately 1,000 to 1,800 ppm H_2S while drilling. The amount of H_2S expected to be encountered from drilling well P-32 would be similar to concentrations emitted from well PS-31.

Federal standards for H_2S emissions are 10 tons per year. Total emissions from well bore modifications and flow testing would be far less than 10 tons per year; however, given the odor and potential threat to human health from H_2S emissions, protection measures have been built into the project to reduce H_2S emissions as much as possible. H_2S control would be accomplished through the installation of a NSCAPCD approved chemical abatement system (as described in *Chapter 2: Proposed Action and Alternatives*).

H_2S emissions would also be minimized through implementation of measures required in the ATC and PTO (Appendix D).

No sensitive receptors are found within 500 feet of the project site, the distance over which odors would dissipate. With monitoring and abatement in accordance with permits, H_2S emissions would not cause adverse effects.

Stimulation

The stimulation phase of the project would involve the continuous flow of water from the newly constructed SRGRP pipeline spur to the re-opened wells at varying rates. An injection program would be designed to study the response of pre-existing fractures in the HTZ by varying pumping rates.

Stimulation would result in the emission of a small amount of steam from the wells if/when venting is required. During venting, the well is “bled” by allowing it to vent a small amount of steam through the well head silencer. Bleeding is usually short term (a few hours) and emissions would include constituents in the geothermal fluid including very small amounts of boron, arsenic, and H_2S. Calpine would notify the NSCAPCD 24 hours prior to initiating any planned venting operations until such time that an emissions release protocol governing emissions and notifications for such operations is prepared and provided to the NSCDAPCD. Operations resulting in an excess of 15 pounds per hour of H_2S would be subject to meteorological forecast per PTO conditions. Emissions would otherwise not occur.

Air emissions of constituents such as boron, arsenic, mercury, and H2S during the testing phase would be similar or less than those emitted during re-drilling. Impacts would not be adverse with implementation of the PTO conditions.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, injection may occur in either or both wells, depending upon the results from the stimulation phase. Impacts would be similar as described for the stimulation phase. Data collection and information assessment includes the long term monitoring and assessment of the closed wells and would not have adverse effects on air quality.

Greenhouse Gas (GHG) Emissions and Global Warming

Construction of the SRGRP pipeline and modifications and re-drilling of the existing wells would result in the emission of some GHGs (mostly from running equipment engines). Emissions would primarily come from the diesel generator on the drill rigs. Approximately 340 tonnes[2] (a metric ton is 1,000 kg, or 2,204.6 lbs, and is commonly referred to as a tonne) of GHG emissions from large bore diesel engines are estimated. Well drilling and testing would also emit CO_2 and methane in the geothermal steam.

Greenhouse gases are typically reported as equivalents of CO_2, or as CO_2e. Methane is a more potent greenhouse gas than CO_2 by a factor of 21, so methane emissions are converted to CO_2e by multiplying by a factor of 21. Greenhouse gas emissions from this project, based on a 30-day expected drilling duration per well would total 1,755 tonnes (calculations are show in Appendix I). The California Air Resource Board has a proposed emissions standard of 7,000 tonnes per year CO_2 equivalent. The project would emit less CO_2 than the standard for construction and drilling activities. Venting during the stimulation phase would also result in some emissions of GHGs; however, with venting lasting only a few hours, the amounts of emissions would be on the order of 1 metric ton per venting, which is a small amount.

The project would help mitigate GHG emissions since it would provide information that may lead to the long term sustainability of the geothermal resource and mitigation of GHG emissions, which could replace fossil fuel energy sources that emit much more GHGs. Fossil fuel combustion-related CO_2 accounts for 82 percent of the total US human-made GHG emissions (NEIC 2007). A comparison of geothermal and fossil fuel CO_2 emissions from electrical generation is shown in Table 3.2-6. Emissions reported in the table are weighted average values for all geothermal capacity, including binary power plants that do not emit CO_2 (Bloomfield et al. 2003).

Table 3.2-6: Geothermal vs. Fossil Fuel CO_2 Emissions for Electrical Generation

	Geothermal	Coal	Petroleum	Natural Gas
Emissions (pounds CO_2 per kilowatt hour)	0.20	2.095	1.969	1.321

SOURCE: Bloomfield et al. 2003

Air Conformity Analysis

The project is not located within any current federal non-attainment areas and would not exceed any conformity requirements as dictated in the EPA's rule "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (40 CFR 93, Subpart B). The project would not contribute to any violation of federal ambient air quality standards.

[2] The amount of GHG emissions was calculated by adding the calculated, worst-case scenario emissions of CO_2 and CH_4 from Table 3.2-3 and converting to tons.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to air resources could occur anyway.

3.3 Geology

3.3.1 AFFECTED ENVIRONMENT

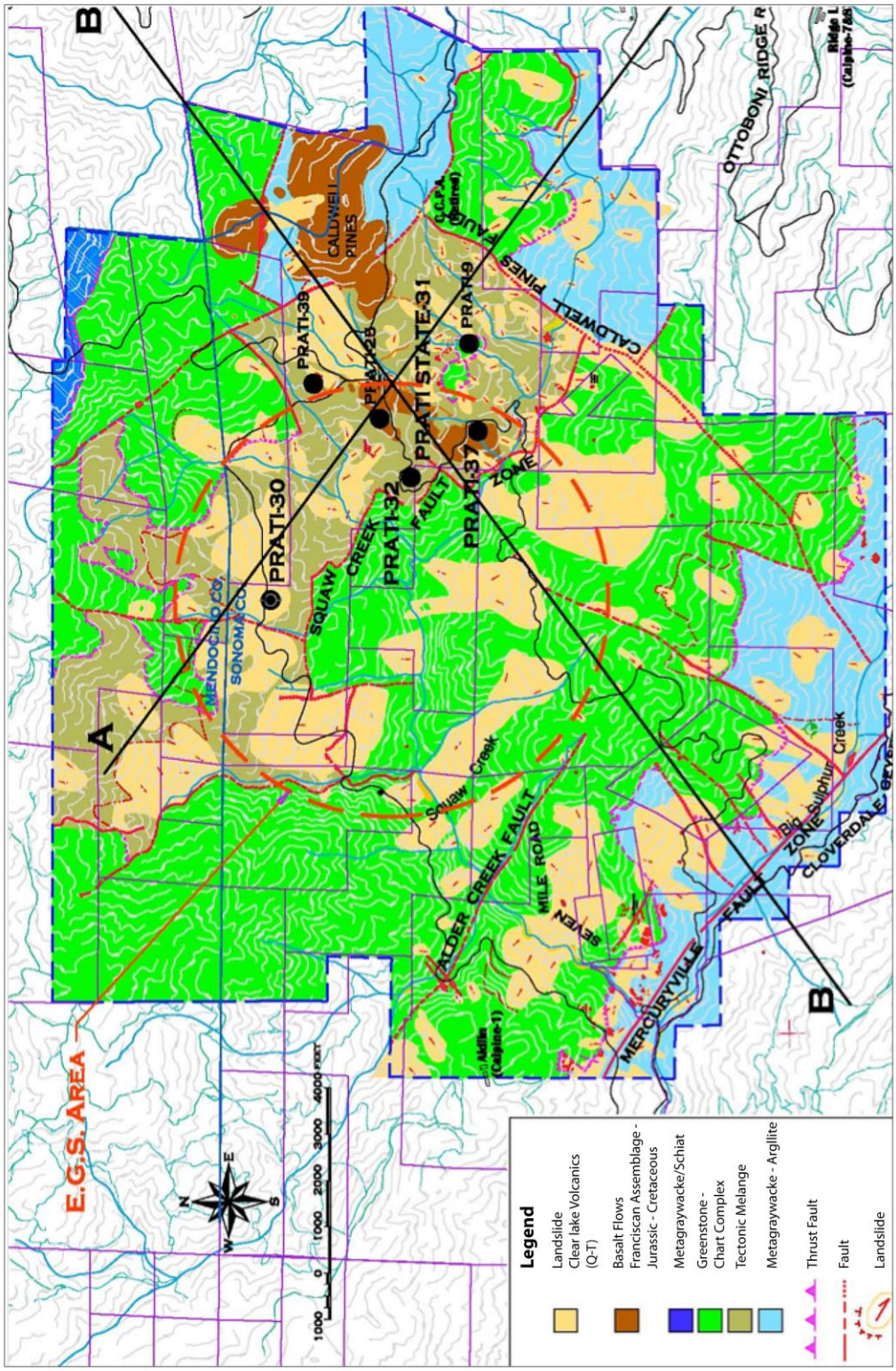
Geology

The Geysers geothermal area is located within the Coast Ranges geomorphic and tectonic province of northern California. The region is underlain primarily by highly deformed and metamorphosed volcanic and sedimentary rocks of the Jurassic-Cretaceous Franciscan assemblage, which are juxtaposed against similarly aged Great Valley Sequence rocks along the Coast Range thrust fault. These older rocks were intruded and overlain by Pleistocene igneous rocks during a phase of late-stage volcanism attributed to the northward migration of the Mendocino triple junction. The Pleistocene rocks crop out to the northeast of The Geysers near Clear Lake and to the east on Cobb Mountain as the Clear Lake Volcanics. Within The Geysers area itself, the igneous rocks are largely confined below the surface. The heat source driving the Geysers geothermal system is postulated to magma body (bodies) located at mid-crustal depths. Overlying the bedrock are a variety of Quaternary deposits, including recent alluvium along river valleys and landslide deposits, which are ubiquitous in areas of steep topography underlain by sheared Franciscan assemblage rocks. A geologic map of the EGS area in the Northwest Geysers is shown in Figure 3.3-1. PS-31 and P-32 are located within an area of tectonic mélange.

Tectonics

The Coast Ranges are characterized by steep and rugged topography with a pronounced northwest fabric. This fabric of northwest-trending ranges separated by subparallel river valleys is controlled by the northwest-striking structures of the San Andreas fault system. The San Andreas fault system is a 100-km-wide swath of subparallel, primarily right-lateral strike-slip faults along the western edge of California. It comprises the boundary between the North American and Pacific tectonic plates and accommodates most of the transform motion between the two plates. The San Andreas fault is the dominant fault in the system, but numerous smaller faults within this 100 km wide swath of strike slip faults accommodate some portion of the plate motion. Faults within The Geysers area include numerous inactive bedrock faults associated with earlier tectonic regimes, as well as a number of faults active in the Quaternary (approximately 2.5 million years ago, through present times). Faults are described in greater detail in the Induced Seismicity Report (URS 2009) attached in Appendix J.

Figure 3.3-1: Geologic Map of the EGS Area in the Geysers



SOURCE: Calpine

Note: None of the faults shown on this map are known to be active within historical or recent times

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The Geysers lies within a zone of right-lateral shear and localized extension between two Holocene-aged (less than 11,700 years) active faults of the San Andreas fault system: the Maacama fault to the southwest and the Bartlett Springs fault to the northeast. The localized smaller faults in the project area are shown in Figure 3.3-2 and Figure 3.3-3. Both these faults have documented Holocene activity, and the Maacama fault is actively creeping along much of its length.

Significant seismicity and crustal deformation has been documented in The Geysers area (Lofgren 1978, Ludwin et al. 1982, Oppenheimer 1986, Mossop 1997). Studies attribute most of the activity to the withdrawal and injection of fluids associated with development of the geothermal resource (e.g., Lofgren 1978, Marks et al. 1978, Oppenheimer 1986). Between the Maacama fault and Clear Lake, however, geodetic studies suggest that there is naturally-occurring active right-lateral shear, east-southeast-directed extension, and regional tectonic subsidence. Extension also is reflected in normal faulting mechanisms and the presence of depositional, pull-apart basins within the region. Regional tectonic deformation rates are about an order of magnitude slower than induced rates (Lofgren 1978).

Seismicity

Historic Seismicity

The historical earthquake record of north-central California dates back to the early 1800's when the region was settled. Until the early 1900's, when the first seismographic stations were installed by the University of California at Berkeley (UCB), the historical record was based on observed intensities. The Geysers and surrounding region exhibited a low level of known seismicity prior to 1960 (see Figure 7 in Appendix J); however, seismographic coverage north of San Francisco Bay was only sufficient to record and locate events ML 4 and larger.[3]

A number of large earthquakes occurred in California prior to 1960 that have probably impacted The Geysers and surrounding region. The two most significant events are the 1906 Great San Francisco earthquake, because of its size and location along the northern San Andreas Fault to the west, and an earthquake in 1955 near The Geysers.

Seismic Monitoring in The Geysers

Seismographic coverage of The Geysers to detect earthquakes smaller than ML 3 began in mid-1975 when the US Geological Survey (USGS) Central California Seismic Network (CALNET) reached The Geysers area (Oppenheimer 1986). The USGS operates an array in The Geysers, which is part of the much larger regional network also operated by the USGS. Since 1976, station density in The Geysers area has been sufficient to determine the location of virtually all seismic events likely to be felt by humans, including thresholds as low as ML 1.2 to 1.5. The system records and locates about 3,000 events per year in The Geysers area. Data from a new LBNL network has recently been integrated into the Northern California Seismic Network (NCSN) system, significantly lowering the magnitude threshold and thereby increasing the number of events captured in the dataset. Local seismic/motion monitoring stations are shown in Figure 3.3-3.

[3] Richter local magnitude [ML] is approximately equivalent to M, or moment magnitude.

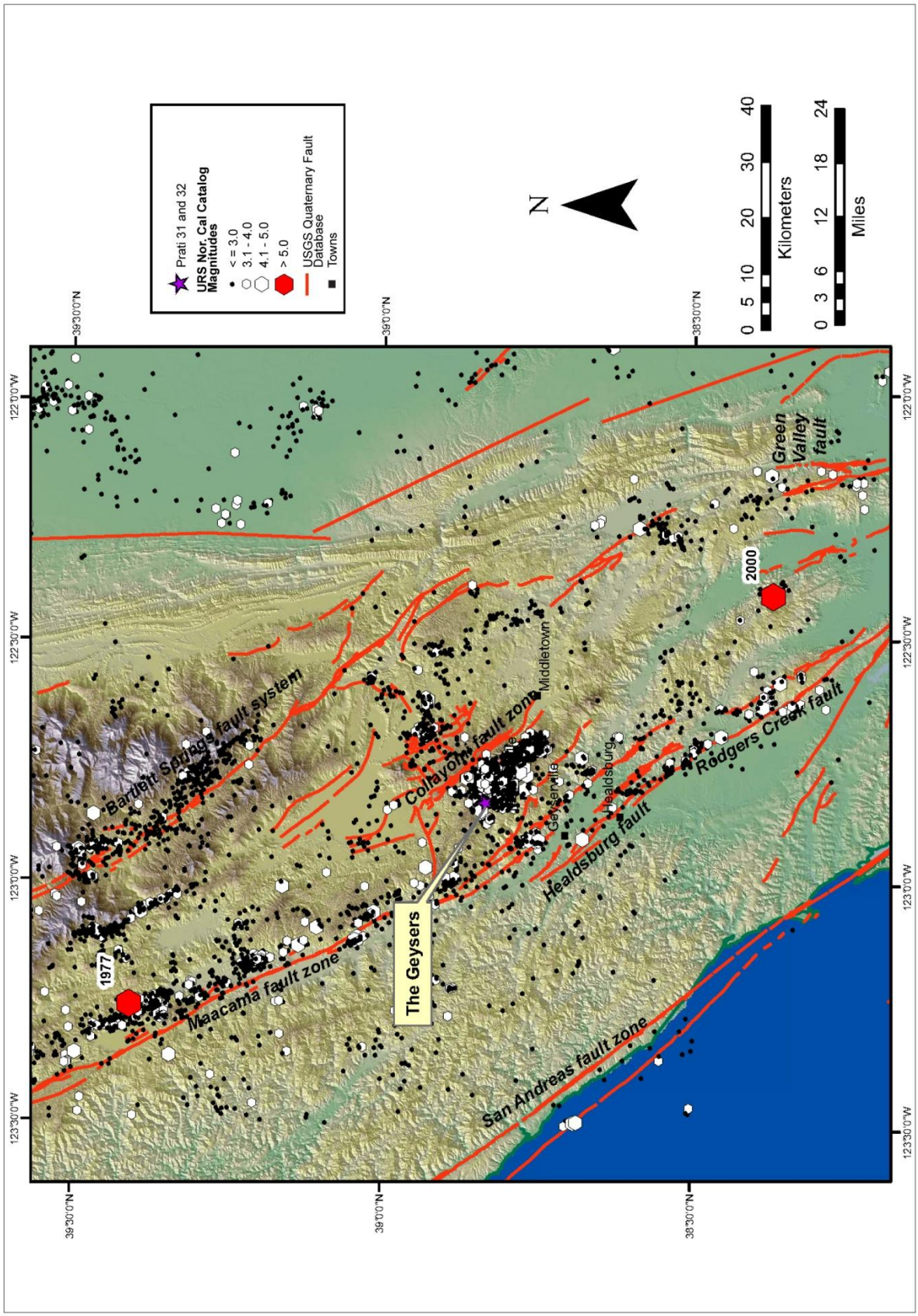
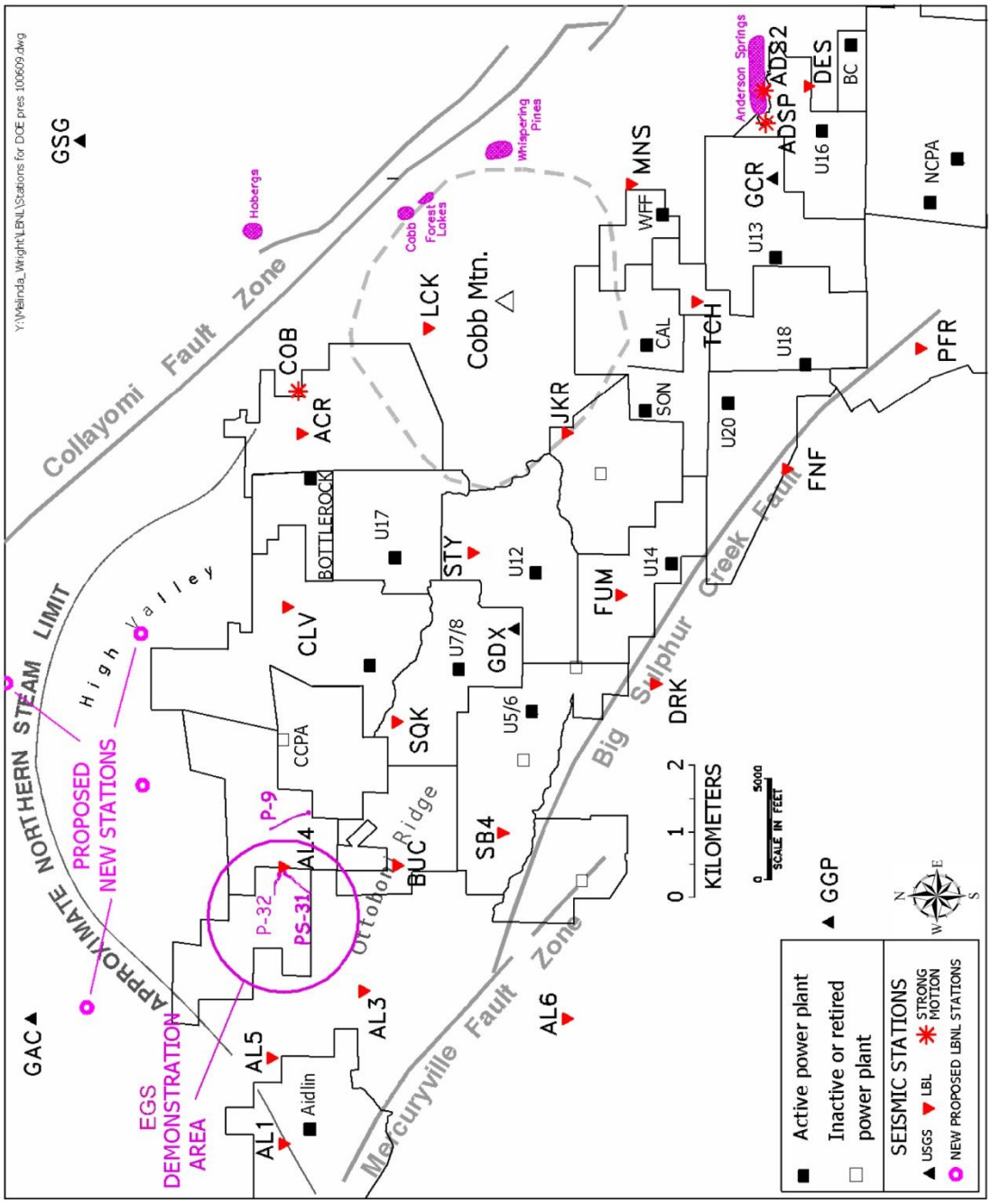


Figure 3.3-2: Faults in the Project Region

SOURCE: URS 2009

Figure 3.3-3: EGS Demonstration Area Distribution of Wells and Seismic Stations



SOURCE: URS 2009

Induced Seismicity

Induced seismicity refers to earthquakes and tremors that are caused by human activity that alter the stresses and strains in the Earth's crust. The Geysers geothermal area is the site of a vapor-dominated steam field from which electric power has been generated since the early 1960's. It is also among the most seismically active areas in California (Figure 3.3-2).

Earthquakes are concentrated at the steam production field and extend to a depth of 6 km (about 20,000 feet) (Eberhart-Phillips and Oppenheimer 1984). The Geysers experienced a very low level of seismic activity prior to the onset of power production. However, few stations for recording seismicity had been in place prior to development of the geothermal resource; therefore, data on background seismicity was limited.

The USGS NCSN catalog lists a total of 25 probable Geysers induced earthquakes of ML or M 4.0 and greater (Table 3.3-1). This translates to a rate of one M ≥ 4.0 event per 1.5 years since 1972. The rate, however, has significantly increased since 2002 to about one M ≥ 4.0 event every 7 to 8 months after a significant increase in injection volume.

The largest earthquake observed in The Geysers has been an estimated ML 4.6 on May 9, 1973 that occurred near the present-day Aidlin project area which was not developed until the late 1980's. This event occurred on the northwestern edge of the present-day concentrated induced seismicity associated with operation of the Aidlin steamfield. Its depth was estimated at about 12 km (about 39,000 feet), but due to poor seismographic coverage of The Geysers at the time, it is unknown if the earthquake was induced or tectonic. Its magnitude is also uncertain (David Oppenheimer pers. comm. 2009). A M 4.5 event occurred on October 20, 2006 on the northern margin of The Geysers area. It is thought to be induced due to its shallow focal depth (3.5 km or approximately 11,000 feet).

DOE Requirements for Evaluation of Induced Seismicity for EGS Projects

Since 2008, the DOE started requiring adherence to the "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" (Majer et al. 2008).). DOE had instituted this requirement in order to follow international protocols to address and mitigate potential impacts resulting from induced siesmicity. Calpine's response demonstrating compliance with the protocol is presented in Appendix K. – Statement of Compliance with DOE Seismic Protocol. The protocol requires several considerations to be made by any proponent proposing to conduct an EGS project with DOE funding.

Geothermal Resource, Natural Resources, and Energy Supply

The Geysers, comprising 30 square miles along the Sonoma and Lake County border, is the largest complex of geothermal power plants in the world and world's largest dry-steam geothermal steam field. Calpine owns and operates 15 of the 18 active power plants at The Geysers with a net generating capacity of about 725 megawatts (MW) of electricity, which is enough to power 725,000 homes, or a city the size of San Francisco. Other power plants in The Geysers include the Bottle Rock Power Plant and two plants owned by the Northern California Power Agency.

Table 3.3-1: Induced Earthquakes at The Geysers (M ≥ 4.0) 1970 to Present

ID	Year	Month	Day	Time	Latitude (degrees)	Longitude (degrees)	Depth (km)	Magnitude	Magnitude Scale	No. of Stations	Gap (degrees)	D_{MIN} (km)	RMS (sec)
1	1972	8	19	1:19:46 AM	38.847	-122.688	1.3	4.2	M_d	8	301	33	0.09
2	1982	5	29	1:02:25 PM	38.801	-122.822	2.2	4.0	M_L	50	25	3	0.07
3	1984	9	22	6:52:03 PM	38.798	-122.823	2.8	4.0	M_L	43	30	3	0.06
4	1985	7	3	10:24:01 AM	38.932	-122.971	5.0	4.3	M_d	4	119	13	0.16
5	1985	8	8	7:03:11 PM	38.792	-122.778	0.0	4.0	M_d	36	34	2	0.37
6	1985	11	12	4:06:57 PM	38.848	-122.772	0.0	4.1	M_L	5	263	3	0.05
7	1990	8	14	7:05:13 PM	38.825	-122.792	2.4	4.1	M_L	45	37	2	0.07
8	1992	9	19	11:04:47 PM	38.860	-122.792	3.9	4.4	M_d	50	34	6	0.06
9	1995	1	16	1:34:38 AM	38.823	-122.797	2.0	4.0	M_d	46	36	2	0.04
10	1996	12	4	9:21:15 PM	38.792	-122.757	2.9	4.1	M_d	47	30	4	0.06
11	1999	2	18	8:58:36 AM	38.785	-122.770	2.2	4.1	**M**	36	39	3	0.05
12	2000	12	8	7:41:11 AM	38.782	-122.767	4.3	4.2	M_L	51	29	4	0.07
13	2003	5	20	4:50:42 PM	38.801	-122.803	0.6	4.1	**M**	55	35	1	0.09
14	2003	8	3	12:00:53 PM	38.799	-122.769	0.9	4.2	**M**	46	37	1	0.06
15	2004	2	18	8:37:46 PM	38.834	-122.768	1.9	4.4	**M**	53	42	1	0.09
16	2004	12	27	10:36:23 AM	38.749	-122.726	3.7	4.3	M_L	46	26	3	0.08
17	2005	5	9	10:37:39 PM	38.789	-122.755	0.3	4.4	**M**	63	32	2	0.12
18	2006	5	12	10:37:29 AM	38.816	-122.817	2.9	4.4	M_L	61	31	2	0.09
19	2006	5	12	10:38:36 AM	38.843	-122.854	2.6	4.2	M_L	21	54	8	0.04
20	2006	10	20	5:00:08 PM	38.867	-122.787	3.5	4.5	**M**	62	39	5	0.08
21	2007	4	24	9:08:29 PM	38.795	-122.797	2.5	4.4	**M**	55	23	1	0.09
22	2008	2	24	5:32:10 AM	38.819	-122.810	3.0	4.0	**M**	60	41	2	0.08
23	2008	5	30	4:48:30 AM	38.779	-122.768	1.0	4.3	**M**	38	61	2	0.06
24	2008	5	30	4:48:37 AM	38.739	-122.752	2.1	4.2	**M**	49	127	15	0.57
25	2009	1	4	17:27:10 PM	38.7823	-122.773	4.7	4.3	**M**	66	25	1	0.08

SOURCE: URS 2009

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The Geysers meets the typical power needs of Sonoma, Lake, and Mendocino counties, as well as a portion of the power needs of Marin and Napa counties. The Geysers satisfies nearly 60 percent of the average electricity demand in the North Coast region from the Golden Gate Bridge to the Oregon border. The Geysers is one of the most reliable energy sources in California delivering extremely high availability and on-line performance and accounts for one-fourth of the green power produced in California.

Steam used at The Geysers is produced from a greywacke sandstone reservoir that is capped by a heterogeneous mix of low permeability rocks and underlain by an intrusive felsite body with an age date of about 1 million years (Enedy et al. 1991). At the Prati 31 and 32 locations, the high temperature zone is found within the greywacke reservoir. The heat source that drives the high temperature zone is presumed to be from a small intrusion with an age estimated by the US Geological Survey to be less than 10,000 years before present. The composition of the presumed intrusion is not known because it has not been reached by any well including PS-31 or P-32. G

The Geysers electrical plants reached peak production in 1987, serving 1.8 million people. The steam field has since been in gradual decline as its underground water source decreases.

Techniques developed from EGS research are increasing the production of the region in the future. The two recycled water projects have increased electrical output by 85 MW, enough for about 85,000 homes.

Soils

The National Resources Conservation Service (NRCS) classifies the soils in the vicinity of the project as listed below and included in Appendix L. Soil types include loams, clay loams, and weathered volcanic (NRCS 1972).

PS-31 and P-32

- Suther-Laughlin loams, 15-50% slopes (SuF): These moderately well-drained soils are on mountainous uplands. They are underlain by sandstone. The Suther soils have concave slopes, and the Laughlin soils are usually on or near ridgetops. The Suther soils are subject to gullying and landslips. Runoff is medium to rapid, and erosion hazard is moderate to high. Vegetation is chiefly mixed annual and perennial grasses, legumes, oaks, and small shrubs.

Pipeline

- Laughlin loam, 50-75% slopes (LgG): These soil series occur on mountainous uplands and ridgetops. The soils formed in materials weathered from sandstone and shale. Vegetation on these soils are either annual and perennial grasses, forbs and small shrubs, or a combination of oaks, grasses and manzanita. Permeability is moderate, runoff is rapid to very rapid, and erosion hazard is high to very high.
- Cohasset gravelly loam, 30-50% slopes (CmF): This steep soil on wooded uplands formed in volcanic materials. Permeability is moderate, runoff is rapid, and erosion hazard is high. Vegetation includes manzanita, and some burned stumps of Douglas fir and tanoak.

- Guenoc gravelly silt loam, 30-75% slopes (GrG): This is a well-drained soil on mountainous uplands. It is underlain by andesitic basalt. Runoff is rapid to very rapid, and erosion hazard is high to very high. Vegetation is mainly grass, oak, and brush.
- Yorkville-Laughlin complex, 30-50% slopes (YvF): This series consists of moderately well drained clay loams on ridgetops, side slopes and mountainous uplands. The soils formed in material weathered from glaucophane-schist, serpentinized igneous rocks, and metamorphosed greywacke. Vegetation is mainly annual and perennial grasses, forbs, with a few oak and madrone trees. Runoff is rapid and the hazard of erosion is high on the Yorkville-Laughlin complex. Less steep slopes have a cover of grass on the Yorkville soil. The Yorkville soil is subject to landslips.

3.3.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Geology, Tectonics, and Seismicity

Construction would not have effects on tectonics or geology in the project region. Re-grading of the well pad and construction of the pipeline would require some ground disturbance but only in previously disturbed areas and construction activities are not expected to encounter bedrock. Some of the grades to the sides of the road by which the pipeline would be installed are steep; however, the pipeline would be installed within the road shoulder on stanchions and would not result in any hazards related to slope stability.

The pipeline could be impacted by seismic events, particularly of tectonic (versus induced) origins. The pipeline would be designed to accommodate the maximum credible earthquake in the project area so as to reduce potential for adverse effects such as pipeline failure in the event of an earthquake.

Geothermal Resource

Construction would have no effect on the geothermal resource. Construction would only occur on the ground surface and would not impact the geothermal reservoir, which is deep below the surface.

Soils

Expansive soils are common throughout The Geysers; however, the proposed project does not involve work in any previously undisturbed areas or previously undisturbed soils. The well pad would be re-graded and drainage containment would be installed to prevent water run-off and erosion of soils. The only structures to be constructed are the stanchions for the SRGRP pipeline spur, which would be constructed using Standard Engineering Methods for Expansive Soils, as necessary. Adverse effects to or from expansive soils would not occur with implementation of these methods for expansive soils.

Erosion would be controlled with implementation of a SWPPP and BMPs. Adverse effects from erosion would not occur.

Well Bore Modifications

Re-drilling and well bore modifications would not impact the tectonics or geology of the area and would not induce seismicity. The project would be conducted on existing wells and would not affect geologic units or faults in the area or the geothermal resource. The wells would require some redrilling and possibly deepening by 500 feet (for PS-31). Re-drilling and slight deepening would not impact tectonics or geology. Drilling is localized and would not cause movement on faults. The same geologic units are expected to be encountered during deepening and drilling into these units would not be considered a negative impact on the units.

Flow testing would occur after well completion; however, the volumes of steam released during flow testing would be small in comparison to what is currently drawn from the KGRA and would not impact the resource. Well bore modifications would only occur on the well pad site and would not impact soils. The well pad site is graded and covered in gravel.

Stimulation

Geology, Tectonics, and Seismicity

The Induced Seismicity Report in Appendix J provides additional background research and analysis of the maximum potential earthquake predicted for the EGS project. This section summarizes the results and findings of the report.

Induced seismicity is the major concern with EGS projects. A causative relationship between steam production and fluid injection was suggested in the late 1970's by USGS scientists. That relationship has now been accepted based on numerous studies (e.g., Denlinger and Bufe 1982, Eberhart-Phillips and Oppenheimer 1984, Oppenheimer 1986, Stark 1990, Greensfelder 1993). Although it is clear that steam production and injection causes some seismicity at The Geysers, the exact causative mechanism is still not well defined. Eberhart-Phillips and Oppenheimer (1984) found no direct correlation between the volume of cold water injected or the volume of steam withdrawn and the number of earthquakes per month. Eberhart-Phillips and Oppenheimer (1984) suggested that there are two plausible mechanisms that could explain the induced seismicity at The Geysers:

1. Volumetric contraction due to mass (geothermal steam) withdrawal, which could alter the stress field (the existing conditions and balance of forces in the rock) and cause faulting in the reservoir rock that is already near failure due to the regional stress field, and
2. Aseismic deformation due to regional tectonism may be converted to strike-slip deformation due to an increase in the coefficient of friction along fault surfaces (Eberhart-Phillips and Oppenheimer 1984).

For both mechanisms, Eberhart-Phillips and Oppenheimer (1984) expected seismicity to continue to increase in spite of declining reservoir production and for seismicity to occur in areas where new production is initiated.

The goal of the proposed EGS stimulation is to reopen existing fractures in the HTZ, which would generate MEQs. MEQs may occur from increased shear stress caused by cooling shrinkage (the

rocks "crack" due to shrinkage from the cooling effects of the relatively cool injected water). The environmental repercussions and concerns with re-opening fractures are the magnitude and number of the earthquakes induced, and whether they would negatively impact nearby communities and structures.

Stimulation would include staged injection over 6 months for each well. This is envisioned as a "gentle" progressive stimulation in which cold water is "poured" (under vacuum) into the HTZ. The low pressure injection promotes gradual shear reactivation of existing fractures in the deep reservoir, which would then provide steam into the normal geothermal reservoir.

Other types of more aggressive forms of EGS involve injection under high pressure to cause hydraulic fracturing (i.e., create *new* fractures in the deep reservoir). New fractures could equate to a larger and more dramatic earthquake. This type of EGS was performed in Basel Switzerland and was thought to have caused a 3.4-magnitude earthquake and 3,500 subsequent earthquakes in an urban area of the city occupied by centuries-old buildings. The project in Basel included drilling into a large, historically active fault, in order to use the energy of the fault to create fractures. Calpine's proposed EGS project is different in that the wells are not in or near existing large faults. The goal is to gradually re-open existing fractures rather than to rapidly create new fractures. This is accomplished by applying much less pressure through injection. The amount of pressure that is applied by the hydrostatic column of injected water dictates how dramatic a response occurs in the EGS reservoir. The maximum downhole pressure of the proposed injection is 8 megapascals (MPa), which is substantially below the minimum principal stresses in the rock, which is about 24 MPa in PS-31 and P-32. Injection at a much lower pressure than the minimum principal stresses in the rocks prevents potentially damaging hydraulic fracturing and allows for gradual shear reactivation of existing fractures rather than creating new fractures as proposed in Engineered Geothermal Systems such as the Basel project.

Even though this is an EGS project, the injection response should be similar to injection in other areas of The Geysers in terms of induced seismicity. Recently re-opened well Prati-9 provides data for injection induced seismicity. The largest earthquake recorded at Prati-9 in the nearly two years of injection was a M 2.8, and the induced earthquakes at Prati-9 have not generated any significant shaking at the nearest communities of Anderson Springs and Cobb (URS 2009).

Ground shaking from induced events at PS-31 and P-32 is expected to be even less than at previously re-opened wells such as Prati-9 because PS-31 and P-32 are further from Anderson Springs and Cobb. The maximum predicted event from the proposed project is a M 4.5. If this sized event were generated, the ground shaking would be felt in the nearby communities at a moderate Modified Mercalli Intensity level that is not associated with structural damage. This size earthquake could also occur from tectonics or from the existing geothermal activity in The Geysers. Such an event is unlikely to occur given that only one M 4.5 event has occurred over the past 40 years over the entire area of The Geysers (Wong et al. 2010).

The resulting induced seismicity would be very closely and extensively evaluated for patterns that might indicate an increased rate of larger events that might be felt in Cobb and Anderson Springs. The project includes a detailed modeling and monitoring program and therefore, if such patterns emerge, the injection strategy would be modified to mitigate for such effects.

While non-damaging microseismic activity may increase, the chances of inducing a much larger event are negligible. In general, seismicity induced by geothermal injection increases as the rate of fluid injection increases. Seismicity is also dependent on the amount of fluid injected into the ground, the increase in pore pressure in relation to the orientation of the stress field, the extensiveness of local faults, and the preexisting excess stress on the local faults (Majer 2008). Local faults are not known to be extensive, the project would not include drilling or injecting into any major faults, and the injection wells are not deep (approximately 9,500 feet deep). Majer believes that injection needs to be greater than 15,000 feet deep to induce significant faulting (Majer 2008). The proposed action is therefore not likely to result in any considerable and damaging seismic activity.

Geothermal Resource

It is anticipated that the proposed project would have a positive impact on the geothermal resource. The goal of the injection is to reduce the NCG concentration in the steam in the EGS area by 30-50 percent, to provide a more efficient use of water to generate injection-derived steam, and to support mass replacement in the reservoir, thereby sustaining the energy production potential of the reservoir.

Soils

Stimulation is not expected to impact soils. Some venting of steam may occur during stimulation and low level constituents, such as arsenic and boron, may settle out of the steam onto the ground, but concentrations would be especially low and would wash away with rain.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, injection may occur in either or both wells, depending upon the results from the stimulation phase. Impacts would be similar as described for the stimulation phase and the injection rate would be modified to minimize induced seismic effects to the communities. Monitoring would not have effects on geology, tectonics, or the geothermal reservoir as it would only involve monitoring the response using existing equipment and chemical testing.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to geology could occur anyway.

3.4 Biological Resources

3.4.1 AFFECTED ENVIRONMENT

Vegetation

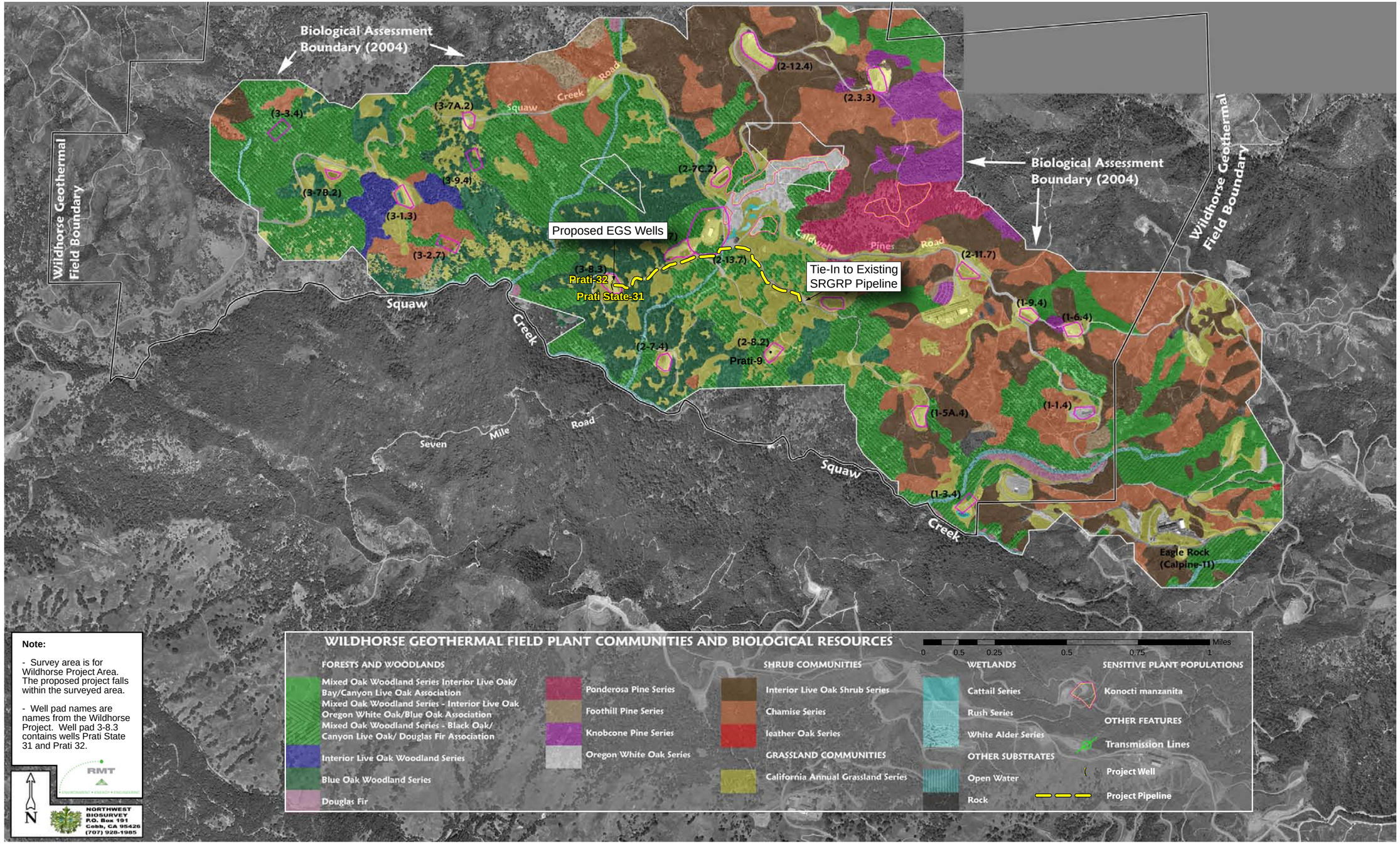
The region supports a variety of brushlands, grasslands, marshland, riparian, woodland, and forest communities. Grassland and herbaceous communities are more limited in distribution, but elements of both native and non-native grasslands can be found scatted throughout the region as understory components of other communities. Where they occur on their own, grasslands are typically dominated by introduced European annuals with California Prairie perennial bunchgrasses and other native vegetation mixed in or found as dominant stands in less disturbed areas.

The well pad and pipeline route is entirely disturbed and comprised of the California Annual Grassland series. California Annual Grassland is a ubiquitous groundcover community and surrounds the existing well pad and SRGRP pipeline location. This community is made up of a wide range of introduced annual grasses.

Adjacent habitats (within 100 feet of the pipeline route) are shown on Figure 3.4-1 and include:

- **Blue Oak Woodland Series.** The Blue Oak Woodland series occurs on relatively dry exposed slopes north of Squaw Creek and is found interspersed throughout the surrounding grasslands. The structure of the community can range from woodland to open savannah with little to no shrub layer and a continuous groundcover of California Annual Grassland series.
- **Mixed Oak Woodland Series-Interior Live Oak.** This highly variable community includes a contribution from canyon live oak and foothill pine. Wherever it occurs, it consists of large mature trees either in a woodland or more open savanna form. On dryer, more exposed, south-facing slopes, blue oak or foothill pine become significant members of the community; in areas where these species dominate, the community is mapped with the appropriate series name. Where a shrub layer occurs, it consists of widely scattered manzanita. The groundcover consists of introduced California Annual Grassland.
- **Blue Oak Woodland Series.** This series occurs as a homogenous blue oak woodland series on the relatively dry, exposed slopes above Squaw Creek. The structure of this community ranges from woodland to open savanna with little or no shrub layer and a continuous groundcover of introduced California Annual Grassland.
- **Knobcone Pine Series.** Dense, homogenous stands of knobcone pine occur as natural communities and as created revegetation sites associated with the closure of CCPA well pads. These dense forests provide 100-percent canopy closure with no shrub or herb layer development (Northwest Biosurvey 2007).

Figure 3.4-1: Habitats in the Project Region



SOURCE: Northwest Biosurvey 2004, Calpine 2009, DOGGR 2009, and RMT Inc. 2009

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Wetland and Riparian Areas

Numerous streams have their headwaters in the Mayacamas Mountains. These streams, especially in their downstream, more perennial reaches, support the primary aquatic habitats in the region. Anadromous fish spawning habitat (e.g., steelhead central California coast Evolutionary Significant Unit (ESU)) can be found in nearby Squaw Creek.

Riparian and wetland habitat communities in the region include Cattail series, Rush series, and White Alder series (Figure 3.4-1). The pipeline route and well pad do not overlap any wetland areas; however, White Alder and Cattail series are both found within 0.25 miles of the pipeline route in one location. Cattail habitat communities are usually found near perennial pools of abandoned well pad sumps, roadside ditches, and in slower reaches of principal drainages. White Alder series is a riparian community most often found throughout principal and perennial secondary drainages of the project region and is most often overtopped by Douglas fir and mixed oak woodland trees from the upland community of adjacent steep slopes.

Invasive Species

Invasive plant species are a fairly common occurrence within the rangelands and drainages of southern Sonoma County. The introduction and expansion of invasive non-native plants in the region can threaten biological diversity and may negatively impact sensitive habitats and species. Most invasive species found in the area are widespread and primarily found in disturbed areas, woodlands and grasslands, or riparian habitats. Non-native invasive species in the project region may include:

- Silver hairgrass (*Aira caryophyllea*)
- Black mustard (*Brassica nigra*)
- Field mustard(*Briza maxima*)
- Yellow starthistle *(Centaurea solstitialis)*
- Bull thistle *(Cirsium vulgare)*
- Poison-hemlock *(Conium maculatum)*
- Quackingrass *(Briza maxima)*
- Soft brome *(Bromus hordeaceus)*
- Red brome *(Bromus madritensis ssp. Rubens)*
- Tall fescue *(Festuca arundinacea)*
- Italian ryegrass *(Lolium multiflorum)*
- Pennyroyal *(Mentha pulegium)*

Most of the invasive species found in the area are widespread and primarily found in previously disturbed areas and roadside ditches, woodlands and grasslands, or riparian habitats (Cal-IPC 2006).

Wildlife

Several wildlife species are known to occur in the general project vicinity and include black-tailed deer (*Odocoileus hemionus columbianus)*, California quail (*Callipepla californica*), mountain quail (*Oreortyx pictus*), mourning dove (*Zenaida macroura*), band-tailed pigeon (*Columba fasciata)*, wild

turkey (*Meleagris gallopavo*), black-tailed jack rabbit (*Lepus californicus*), brush rabbit (*Sylvilagus bachmani*), and western gray squirrel (*Sciurus griseus*).

The rural setting of the project area supports many raptor and migratory bird species in the surrounding woodlands.

Protected and Special Status Species

Special status species are species that have a designation of endangered, threatened, or a species of concern under either the federal Endangered Species Act (ESA) or the state ESA (as defined by the California Department of Fish and Game (CDFG)). Other protected species include migratory birds under the Migratory Bird Treaty Act (MBTA) and bald and golden eagles under the Bald Eagle Protection Act (BEPA). Plant species identified as threatened or otherwise rare by the California Native Plant Society (CNPS) are also given consideration.

Several protected and sensitive species were identified for the project region. These species were compiled from the following sources:

- A query of the US Fish and Wildlife Service (USFWS) list of endangered, threatened, and candidate species under Section 7 of the ESA
- Plants occurring on the CNPS Electronic Inventory of Rare and Endangered Vascular Plants of California
- A database search of the California Natural Diversity Database (CNDDB) (CDFG 2009)
- The Biological Assessment with Botanical Survey for the Wildhorse Development Project (Northwest Biosurvey 2007)

The biological report for the Wildhorse Development Project (Northwest Biosurvey 2007) included a survey encompassing 2,050 acres and a full, in-season floristic survey. The Wildhorse Development Project area is much larger than the proposed project area; however, the proposed project falls entirely within the Wildhorse Development Project area that was surveyed (as shown in Figure 3.4-1).

The list of potential special status species, their status, habitat affinities, and potential to occur in the project area are included in Appendix H. Key species that could occur in the area are described below.

Plant Species

Konocti Manazanita

Konocti manzanita (*Arctostaphylos manzanita ssp. elegans)* does not have any federal or state status; however, the species is listed by CNPS as sensitive. It is a subspecies of the common manzanita. It is found in chaparral, lower montane conifer forest and volcanic sediments. It blooms from March to May. Known populations are shown in Figure 3.4-1. The nearest population is located about 150 feet north of the proposed SRGRP spur alignment within Oregon White Oak series habitat and Mixed Oak Woodland series (Northwest BioSurvey 2007).

Avian Species

Sharp-Shinned Hawk

The sharp-shinned hawk (*Accipiter striatus*) is a small raptor that prefers cool, moist, well-shaded forest with access to water. It is a California Species of Concern and prefers White Alder series or ponderosa pine and black oak woodland. Nests are usually found in dense stands of conifers near water (Northwest BioSurvey 2007).

Ferruginous Hawk

Typical habitat for the Ferruginous hawk (*Buteo regalis*) consists of isolated perches overlooking open grassland and scrubland for hunting. This species is a California Species of Concern. Suitable wintering habitat for this species occurs in mixed oak woodlands in the project region (Northwest BioSurvey 2007).

Common Yellowthroat

The common yellowthroat (*Geothlypis trichas*), a California Species of Concern, is a passerine transient species that finds food and cover primarily in wetland habitats. It may also nest in riparian areas and grasslands over water or within dense shrubs. Potential habitat exists in the region along perennial drainages (Northwest BioSurvey 2007).

Yellow Warbler

The yellow warbler (*Dendroica petechia*) inhabits riparian woodland such as the White Alder series with dense shrubby understory for nesting and cover. Potential habitat exists in the region along perennial drainages (Northwest BioSurvey 2007).

3.4.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Vegetation, Wetlands, Riparian Habitat, and Invasive Species

Construction activities include construction of the SRGRP pipeline and re-grading the existing well pad. Construction activities would take place on previously disturbed areas, including some paved areas. Minor removal of vegetation may be required on the well pad and the SRGRP pipeline route (located within the shoulder of the access road (Seven Mile Road)) where vegetation has re-established. Re-established vegetation is limited on access roads because of regular travel, regular maintenance, and the existence of the road substrate covering native soils (i.e., gravel or pavement).

Removal of a small amount of vegetation for construction of the pipeline and re-grading of the well pad would not be considered an adverse effect to the general vegetative communities in the area. Ample habitat surrounds the proposed project site that is of higher quality and is undisturbed. No trees would be removed.

Common invasive species are widespread in the region and would most likely be found in previously disturbed areas such as on the well pad and alongside the access road in the project

area. The removal of invasive species during construction would be beneficial to the area. No work would occur within wetland or riparian habitat. Adverse effects to vegetation, wetlands and riparian habitat would not occur.

Wildlife

Removal of vegetation for well pad preparation and construction of the SRGRP pipeline may displace a few common small mammals and reptiles; however, the surrounding habitat is plentiful and adequate to support these animals such that they would not be adversely impacted.

Several large pieces of equipment, as well as trucks and worker vehicles, would access the project site. Vehicles could crush or injure terrestrial wildlife. Keeping vehicles at low speeds would reduce the potential for wildlife mortality. Some mortality of common species, such as lizards and voles, would not be considered a significant adverse impact due to the abundance of these species.

Noise from construction may cause minor impacts to wildlife. Increased noise levels could deter common small mammalian species from occupying the site; however, there is abundant land and habitat nearby for these animals. This impact would not be considered adverse.

Protected and Sensitive Species

No rare or sensitive plant species are expected to occur at the project site. The project pipeline would be constructed on stanchions in the shoulder of the existing graded road. No new areas of ground disturbance would be required to construct the pipeline. The only special status plant identified in the project region is the Konocti manzanita. This species is known to occur about 150 feet away from one section of the pipeline alignment as shown in Figure 3.4-1. The pipeline completely avoids Konocti manzanita. The existing well pad would be re-graded. The currently disturbed nature of the pad as a graded and gravel-covered surface precludes the occurrence of special status plant species. No work would occur beyond the boundaries of the existing pad. No impacts to special status plant species would occur.

Special status avian species known to occur in the project area include:

- Sharp-shinned hawk
- Common yellowthroat and yellow warbler

The sharp-shinned hawk, common yellowthroat, and yellow warbler could breed in oak or riparian woodlands adjacent to the proposed construction areas. Construction noise could cause a significant impact on the nesting of any of these species or other migratory birds. The project includes several measure that require pre-construction avian surveys for each species that could breed in the project area and avoidance until fledging is completed for any active nests identified in proximity of the construction area. The details of the measures by species are identified below:

- **Yellow warbler and Common Yellowthroat:** Any work proposed within riparian woodland habitat between April 1 and August 31 would be surveyed by a qualified biologist. If a nest of either species is discovered within 200 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.

- **Sharp-shinned hawk:** Any work proposed within 500 feet of riparian woodland series such as white alder or cattails series, between April 1 and August 31 would be surveyed by a qualified biologist. If an active nest is found within 500 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.

Avian species protected under the MBTA, such as the ferruginous hawk, could also forage near the project area. These species would likely stay away from the construction area due to the noise. The loss of foraging habitat during construction would be temporary and there is an abundance of surrounding areas for foraging.

Raptors could be significantly impacted by noise if construction were to occur between April 1 and August 31. If construction is to occur during this timeframe, pre-construction surveys would be performed in all construction areas within 500 feet of suitable habitat for raptors. If active nests are found, work within these areas would be halted until after August 31 or until a qualified biologist has determined the nest is no longer active and the young have fledged. Adverse effects to avian species would not occur.

Well Bore Modifications

Vegetation and Invasive Species

The EGS wells are existing wells located on an existing pad. Well testing would include the discharge of steam condensate. Elevated levels of constituents such as boron and arsenic may disperse and settle in the vicinity of the pad during testing; however, the concentration of constituents that reaches the ground would be minor, the area affected would be relatively small compared with the vegetation in the region, and the constituents would likely further dilute and wash away during rain events. Effects to general vegetation would not be adverse. Activities necessary to modify the wells would only occur on the existing gravel pad, and therefore, would not spread invasive species.

Wildlife

Noise from operating drill rigs would be above ambient levels in the immediate vicinity of the drilling, but ample habitats for birds, mammals, and herptiles exist in the surrounding areas; wildlife would be able to avoid these disturbances and would not be adversely affected by drilling noise.

Protected and Sensitive Species

Well bore modifications would only occur on the existing pad and would not directly impact any special status plant species. Breeding habitat for yellow warbler, common yellowthroat, and sharp-shinned hawks does not occur within 500 feet of the well pad. Drilling noise would not adversely affect these species. Blue Oak Woodland surrounds the pad. Other protected raptors could breed in this habitat and could be disturbed by drilling noise and activities required for well bore modifications. If well bore modifications (including drilling) were to occur between April 1 and August 31, pre-construction surveys for breeding raptors would be performed within 500 feet of the well pad. If active nests are found, well bore modifications would be halted until after August 31 or a qualified biologist has determined the nest is no longer active and the young have fledged.

Stimulation and Long Term Injection, Data Collection, and Monitoring

The stimulation phase of the project would involve the continuous flow of water at varying rates from the newly constructed SRGRP pipeline to the re-opened wells. The wells would be closed and monitored during the data collection and monitoring phase, with periodic short-term flow testing during that monitoring period. Stimulation and long-term injection, data collection, and monitoring of the geothermal wells would not have an adverse effect on general vegetative communities. Stimulation and monitoring activities would not require removal of vegetation; access to and from the wells and project components would be on gravel or paved access roads and pathways. Data collection and assessment would be done remotely and would have no impact on vegetation, wildlife, or special status species. Stimulation, data collection, and monitoring would not cause the spread of invasive species. Short-term flow tests (steam venting) would occur during stimulation; however, venting would only occur occasionally for short periods of time (about 8 hours). Noise impacts during this phase would be negligible and would cause minor, but not adverse, effects to wildlife.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact to biological resources could occur anyway.

3.5 Water Resources

3.5.1 AFFECTED ENVIRONMENT

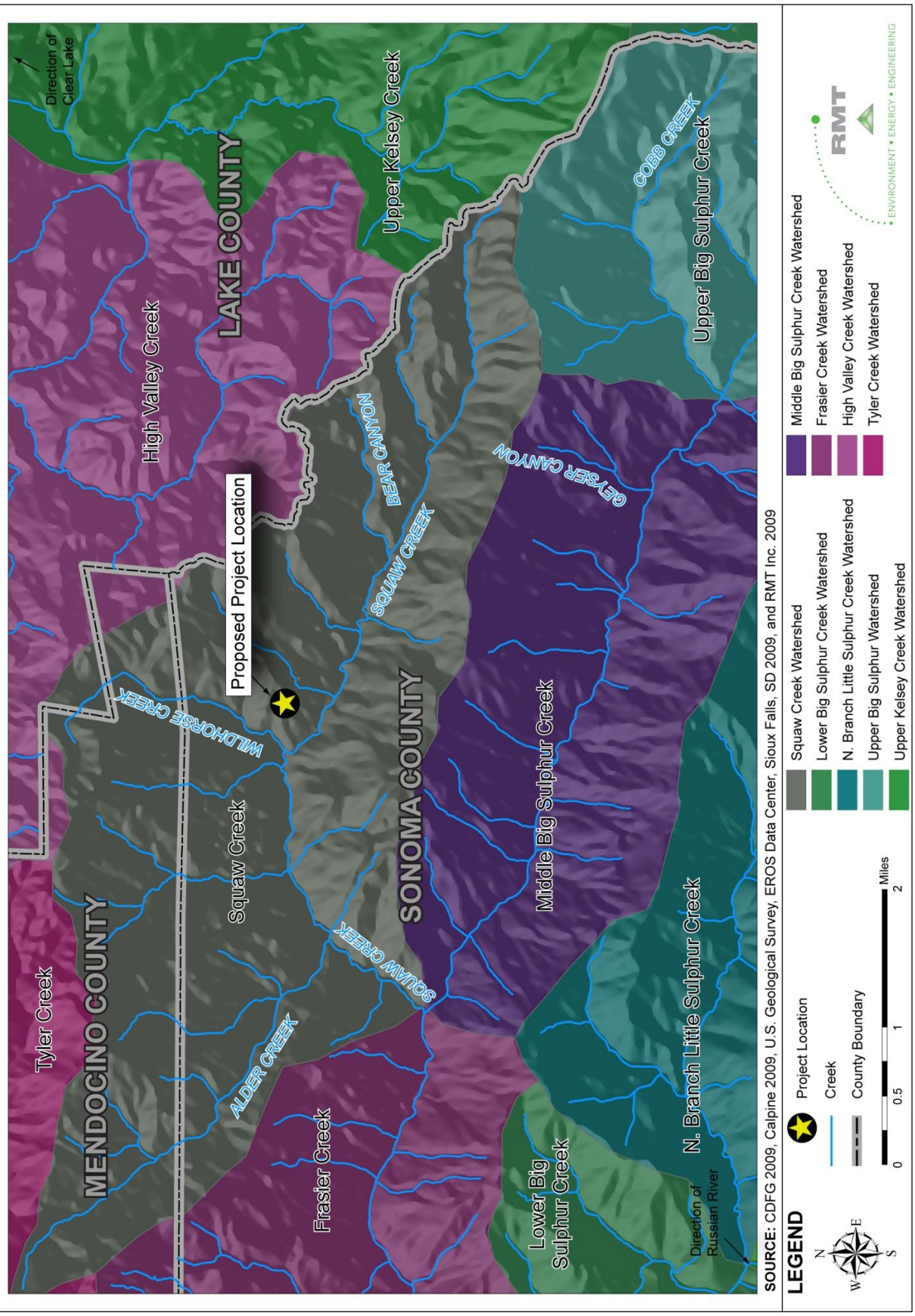
Surface Water Hydrology

The project site is located in the Mayacmas Mountains at an elevation of approximately 2,100 feet above mean sea level (amsl). The Geysers is located within the Big Sulphur Creek and Squaw Creek Watersheds, which are tributaries of the Russian River.

The average seasonal precipitation in the mountains of the project region can be in the range of 70 to 80 inches (Sonoma County 2008). Storm events typically occur between November and April. There is no snow pack during winter and intermittent snows melt off after a few days.

The topography is rugged and runoff is quickly directed into stream channels. Runoff at the project site typically flows downgradient to either Wildhorse Creek or Squaw Creek, which are located to the west of the project area (Figure 3.5-1). During summer months or periods with infrequent rainfall, these tributaries may dry up.

Figure 3.5-1: Surface Waters in the Project Area



SOURCE: CDFG 2009, Calpine 2009, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 2009, and RMT Inc. 2009

The largest nearby surface water body is Clear Lake, located 10.3 miles to the northeast of the project area.

Groundwater Hydrology and Use

According to the California Department of Water Resources (DWR), the project is located within the North Coast Hydrologic Region; however, the groundwater-yielding basin within Sonoma County is located to the south of the project area (DWR 2009). No regional groundwater aquifers of significant yield have been reported in the Mayacmas Mountains near The Geysers (Sonoma County 2005).

Water Quality

Surface and Ground Water Quality

Groundwater is limited in the project region; however, the nearest groundwater basin is the Alexander Valley Groundwater Basin, Cloverdale Area Subbasin. Water quality where groundwater occurs in this basin is characterized as moderately-hard to hard (water that is high in minerals such as calcium and magnesium) and is generally suitable for all uses (DWR 2009). Groundwater within the Cloverdale Area Subbasin has detectable total dissolved solids (TDS) levels between 130 and 304 milligrams per liter (mg/L) and three wells have had boron levels exceeding 0.5 mg/L. Boron values are not expected to restrict uses of the water.

Water Quality Regulations

Water quality is regulated by the federal Clean Water Act (CWA). Important applicable sections of the CWA include the following:

- Sections 303 and 304 provide water quality standards, criteria, and guidelines.
- Section 401 requires an applicant for any federal permit that proposes an activity that may result in a discharge to waters of the US to obtain certification from the state that the discharge will comply with other provisions of the CWA. Certification is provided by the Regional Water Quality Control Board (RWQCB).
- Section 402 establishes the National Pollutant Discharge Elimination System (NPDES), a permitting system for the discharge of any pollutant (except for dredged or fill material) into waters of the United States.
- Section 404 establishes permit programs for the discharge of dredged or fill material into waters of the United States. This permit program is administered by the United States Army Corps of Engineers.

Calpine has a Waste Discharge Order (WDO) [Order No. R1-2009-0103], last revised and approved December 10th 2009 for their activities at The Geysers.

3.5.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Surface Water Hydrology

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. The well pad would be re-graded and a perimeter earthen berm would be constructed. Drainage culverts would be constructed and sub-grade water collection points, for the retention of storm water and as a contingency for spills from the drilling operation, would be installed. The installation of the drainage system would minimize potential adverse impacts to surface water hydrology in the project area.

The construction of the 1.0 mile long SRGRP pipeline spur would occur along the shoulder of existing access roads, creating no new ground disturbance in previously undisturbed areas. The pipeline would be installed on stanchions in the road shoulder. The limited footprint of the stanchions would not have an adverse impact on surface water flow and run-off. Erosion control methods and BMPs would be utilized (such as certified weed-free straw waddle) to reduce erosion or siltation on- or off-site. No water would be released to the surface from the pipeline during testing or operation of the pipeline.

Construction activities may require water for dust control. This water is expected to saturate the ground in the vicinity of the road and would not create the potential for water runoff that could alter the local hydrology.

Groundwater Hydrology and Use

All non-potable water necessary for well pad grading and construction of the SRGRP pipeline would be supplied by the existing Calpine entitlements or the SRGRP pipeline. Adverse effects to groundwater would not occur.

Water Quality

The project would not violate any water quality standards or WDRs. The North Coast RWQCB Board Order No. R1-2009-0103 covers the project area. A SWPPP would be developed and a Notice of Intent would be submitted prior to grading or construction activities.

Stormwater run-off could become contaminated with petroleum fuel, oil, or grease from construction vehicles and equipment and from drilling mud and fluids. Contamination of stormwater run-off at the drilling pad would be minimized through installation of the drainage system and collection of run-off in the reserve tank. Contamination during construction along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater. Calpine would implement an SPCC on-site to contain incidental drips and/or spills. Containment berms would be constructed around all hazardous material or potentially hazardous material storage for both construction and operation. The plans would identify equipment and procedures used for containment and recovery of accidental spills.

Well water (under current Calpine entitlements) or tertiary treated recycled water from the existing SRGRP pipeline would be used for dust suppression. This water has undergone tertiary treatment and complies with all applicable water quality standards for ground application for dust suppression. Adverse effects to water quality would not occur.

Well Bore Modifications

Surface Water Hydrology

Well bore modifications would not have effects on surface water hydrology. All re-drilling would occur from within the well pad, which would have a drainage system installed to contain stormwater. Adverse effects to surface water hydrology would not occur from well bore modification activities.

Groundwater Hydrology and Use

Well re-drilling would require approximately 20,000 gallons of water per day (approximately 14 gpm), for 30 days, for each well, which would come from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP pipeline. No other groundwater users (besides Calpine) are located in the area. No adverse effects would occur from temporary use of groundwater for drilling water supply.

Water Quality

Well bore re-drilling and testing would not impact water quality. The wells would be cased and BOPE would be installed to minimize blowouts or contamination of the localized shallow aquifer as required by CDOGGR regulations. A blank liner would be installed through the normal temperature geothermal reservoir and perforated liners would be installed through the HTZ reservoir. Blank liners do not let fluid pass into or out of the well, while perforated liners allow for fluid exchange. The surface casing and cemented blank liners would minimize cross contamination of constituents from the reservoir into usable groundwater. Adverse effects to water quality would not occur.

Stimulation

Surface Water Hydrology

Stimulation would include the injection of water from the SRGRP pipeline into the injection wells. Stimulation would have no impacts on surface waters or hydrology as it would not involve any water discharge to the surface. Injection would occur through an automated injection system installed at the well head.

Groundwater Hydrology and Use

No groundwater would be used for stimulation. Injection water would be provided by the SRGRP. The injection rate would range between 100 and 800 gpm, depending on the ability of the fracture to accept the fluid. The SRGRP provides 11 million gallons of water per day (7,638 gpm) to The Geysers and would have ample supply necessary to provide the proposed project with injection water.

Water Quality

Surface water would be unaffected by injection. Injection would occur through an automated injection system installed at the well head. Groundwater is limited in the project area and would be protected from injection through casing and liners.

Injection would occur under an updated WDO that would address injection of effluent and condensate into the EGS wells. The injection reports would also be submitted to the CDOGGR. Injection of water and disposal of waste discharge due to drilling would comply with all requirements outlined in the permit.

Injected water would be from the SRGRP tertiary treated recycled water. This water would be injected into the HTZ. This water would have fewer constituents than that found in steam in the HTZ (e.g., constituents found in noncondensable gases). Therefore, stimulation is expected to have a positive impact on the quality of the steam from the HTZ.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects to surface water hydrology, groundwater hydrology and water quality would be similar to those described for the stimulation phase.

Surface hydrology and groundwater hydrology and use would not be impacted as no activities would occur on the surface and no groundwater resources would be used. Effects to water resources would not be adverse. Effects to the geothermal reservoir are addressed in *Section 3.3 Geology*.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to water resources could occur anyway.

3.6 Cultural Resources

3.6.1 Affected Environment

Prehistory

Prehistoric sites in the general project region show affinities to prehistoric cultures that lived to the north in Mendocino County, the east in Lake County, and to the south in the San Francisco Bay area. Numerous prehistoric sites have been recorded in the general geographic area in which the project is located. Hundreds of sites were recorded in the Geysers area during an intensive survey of more than 64,000 acres (Fredrickson 1976a, b).

Historic Settlement

The historic settlement of Sonoma County began with the Russian settlement of Fort Ross, which was founded in 1812 on the Sonoma Coast. Sonoma Mission (Mission San Francisco de Solano), which was designed to prevent further Russian settlement inland, was founded in 1823. Operational aspects of the Califomia mission system resulted in disastrous consequences for the indigenous peoples throughout Northem Califomia, including the Southem Pomo, who occupied the patt of Sonoma County in which the project is located (Ashcroft 2004, Cook 1976).

With Mexican independence from Spain in 1821, large ranchos were established throughout northern California, including 27 on land grants in Sonoma County (Sonoma County Historical Society 2004). Cattle ranching and timber became the economic mainstay in Sonoma County until the Gold Rush, when the large population influx created a demand for other consumer products, most notably dairy products.

In 1859, a mining district was organized in the project area based on the abundant indications of mercury ore (cinnabar or mercury sulfate) in the area. The Cloverdale quicksilver mines near Big Sulphur Creek were operating a furnace by 1877. Eventually, interest in mercury mining faded due to financial losses. Interest was revived in 1972 when the price of mercury (quicksilver) increased to attractive levels. Geothelmal energy was first tapped commercially at the Geysers in the 1920s, when steam from shallow wells was used to generate electricity for a resort on Big Sulphur Creek.

By 1955, full-scale commercial development had begun (Atkinson 1988). The Wildhorse steamfield was originally developed by Geothermal Resources International in the 1980s. Well site pads with associated drilling waste sumps were constructed, along with roads, pipelines, transmission lines, and other appertenant facilities, to supply steam to the Central California Power Agency (CCPA) No.1 Power Plant, which began commercial operation in 1988. CCPA No. I Power Plant and steamfield were placed on long-term lay-up condition in 1996 and were later decommissioned. The plant decommissioning, plugging, and abandonment of the wells and the subsequent restoration activities occurred from 1999 through the early 2000s (WSA 2005).

Ethnography

Archaeological data in the region indicates that the part of Sonoma County in which the project is located was occupied, at least intermittently, for the past six millenia. The projects location borders on three different Native American cultural groups: the Pomo, Wappo, and Lake Miwok. Since the period of initial contact with Europeans, the main native inhabitants of the area have been the Southem Pomo. The Southem Pomo are one of the seven subdivisions within the linguistic group known as the Pomo, and are historically one of the largest groups of Native Califomia peoples. The Southem Pomo are known to have established villages in Sonoma, Lake and Napa counties. Their territory lay in Sonoma County and extended five miles south of Santa Rosa, northward for 40 miles nearly to the county border, and from the Russian River's castem drainage, westward to Kashaya and Central Pomo territory, with a narrow extension to the coast between the two different Pomo groups (Heizer 1978). The project's southern location also borders on Wappo territory, and it is known that the Wappo crossed through Pomo territory on their yearly migration to Clear Lake. Wappo territory extended from Cloverdale and Middletown in the north,

to areas around Napa's northem border. The Wappo's annual journey to Clear Lake may have lead to the formation of a pemlanent Wappo conclave located at the southern end of Clear Lake (Heizer 1978). The Lake Miwok inhabited areas near the project site, but do not seem to have inhabited or used the land that the project site is located (WSA 2005).

Cultural Studies

The proposed project area has been covered by several surveys since 1974. The most recent surveys were conducted by William Self Associates (WSA) in 2005 and 2007 for the Wildhorse Development Project area. The proposed project area falls within the area assessed for the Wildhorse Development Project. The report was prepared to identify and analyze the potential impacts to cultural resources in the area.

Twenty two cultural resource studies have been conducted in or within a 1/4 mile radius of the Wildhorse Development Project area. WSA archaeologists surveyed five block areas totaling approximately 38 acres and along existing unpaved roadways totaling approximately 17 acres. Those surveyed included a portion of the roadway that would provide access to the proposed project's location and on which the pipeline spur would be constructed. No cultural resources were found along the portion of roadway surveyed in 2005 and 2007(WSA 2005; WSA 2008).

A summary of the surveys that included portions of the project area is included below.

- The well pad site containing PS-31 and P-32 was surveyed in 1974 (Fredrickson 1974). No resources were found.
- The access road on which the proposed pipeline spur will be constructed, up to the junction with Seven Mile Road (leading to well Prati-9) was surveyed in 1975 (Fredrickson 1975), and resurveyed in 2005 by WSA. The additional spur up to the junction with Coldwater Creek Road and West Sqauw Creek Road was resurveyed in 2007 by WSA. No cultural resources were found in any of these surveys.
- The remaining portion of the proposed pipeline route along West Squaw Creek Road to the proposed pipeline tie-in location was surveyed in 1975 (Fredrickson 1975). Two sites were identified along this road.
  - P49-775 (initially identified as CA-SON-834 in 1975 report). This site was revisited by WSA in 2007 and is described further below.
  - P49-780 (initially indentified as CA-SON-839 in 1975 report), located on either side of Squaw Creek Road.

Site P49-775 was reevaluated by WSA in 2007. The site was found to no longer exist during this survey due to the all the previous road construction and general disturbance from historic activities associated with geothermal activity (WSA 2008). The original site included obsidian flake scatter and was a probable midden (a pre-historic refuse collection).

Site P49-780 has not been revisited since the 1970s. However, the site is described in the 1975 report and summarized in the Wildhorse A-2 Geothermal Field Development Project Draft EIR (Environmental Science Associates 1984) as a scatter of obsidian flakes having poor integrity because of heavy damage from the previous construction of the road through the area and site. The road has been in constant use for over 35 years.

3.6.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

The proposed project includes some drainage work on the existing well pad, entirely within the currently disturbed area that defines the pad. Pipeline stanchions would be installed for a 1 mile length of pipeline; however, the stanchions would be installed within the shoulder of the existing roads. All work would occur in the existing roadway and would not require disturbance of previously undisturbed areas. Staging would occur along the road and at the well pad. Pipe would be stored only in approved, previously disturbed, staging areas.

A condition from the Wildhorse Development Project has been incorporated into the proposed action to further protect cultural resources. The condition requires placing the following note on all construction plans and providing the language to all contractors and superintendents on the job site: "Should any previously unknown historic or prehistoric resources, including but not limited to charcoal, obsidian or chert flakes, grinding bowls, shell fragments, bone, pockets of dark, friable soils, glass, metal, ceramics, wood or similar debris, be discovered during grading, trenching or other on-site excavation, earthwork in the vicinity of the find shall cease, and the County of Sonoma Permit and Resource Management Department (PRMD) staff shall be notified so that the find can be evaluated by a qualified archaeologist (i.e., an archaeologist registered with the Society of Professional Archaeologists). When contacted, a member of PRMD Project Review staff and the archaeologist shall visit the site to determine the extent of the resources and to develop proper mitigation measures required for the discovery. No earthwork in the vicinity of the find shall commence until a mitigation plan is approved and completed subject to the review and approval of the archaeologist and Project Review staff."

The proposed pipeline spur along West Squaw Creek Road has not been surveyed recently; however, the road has been heavily used for greater than 35 years. Site P49-775 was determined to no longer exist in surveys conducted by WSA in 2007, and therefore, the project would not impact this site. This site is also north of the edge of the paved road, while the pipeline would be installed within the road edge. Site P49-780 was not revisited in 2007; however, in 1975 the site was described as heavily disturbed by previous road construction. The project includes a requirement that a qualified archaeological monitor be present during pipeline construction along all of West Squaw Creek Road to the tie-in location to ensure that no construction activities occur outside of the existing disturbed road shoulder and to monitor for cultural materials during construction. If a resource is found during construction, the monitor shall have the authority to stop construction until it can be further evaluated. The pipeline would be installed above-ground on stanchions, such that ground disturbance is already minimized to only the stanchion footings. The stanchions are a comprised of a piece of wood about 16 by 2 by 4 inches (the wood "sleeper"). The piece of wood is anchored into the ground by 2 pieces of rebar, which are pushed about 4 feet into the ground. Any resource found would be avoided by spanning over the resource and/or moving the pipeline to avoid the resource.

3.7 Noise

3.7.1 AFFECTED ENVIRONMENT

Noise Definitions

Noise is defined as unwanted and objectionable sound. The objectionable nature of sound can be caused by its pitch (the height or depth of a sound) or its loudness. Sounds with higher pitch seem louder to humans than sounds with lower pitch. Sound levels are usually measured and expressed in decibels (dB) with 0 dB corresponding roughly to the threshold of hearing. The method commonly used to quantify environmental sounds consists of evaluating all frequencies of a sound in accordance with a filter that reflects the fact that human hearing is less sensitive at very low and very high frequencies compared to mid-range frequencies. This is called "A" weighting, and the dB level measurement is called the A-weighted sound level (dBA).

A-weighted sound level (dBA) is expressed on a logarithmic (power of 10) scale using a frequency-weighted pattern that duplicates the human ear's sensitivity to sound. A 70 dBA sound level is approximately twice as loud as a 60 dBA sound level and four times as loud as a 50 dBA sound level. Table 3.7-1 lists the definitions of various acoustical terms used in this analysis.

Ground-borne Vibration

Vibrating objects in contact with the ground radiate energy through the ground. Vibrations from large and/or powerful objects are perceptible by humans and animals. The rumbling sound caused by vibrating surfaces is called ground-borne noise. Ground motion caused by vibration is measured as particle velocity in inches per second, and in the United States is referenced as vibration decibels (VdB) (Caltrans 1998).

The background vibration velocity level in residential and educational areas is usually approximately 50 VdB. The vibration velocity level threshold of perception by humans is approximately 65 VdB. A vibration velocity level of 75 VdB is the approximate dividing line between barely perceptible and distinctly perceptible levels for most people.

Typical outdoor sources of perceptible ground-borne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads. If a roadway is smooth, the ground-borne vibration from traffic is rarely perceptible. Ground-borne vibrations generally lie within the range of approximately 50 VdB, which is the typical background vibration velocity level, to 100 VdB, which is the threshold where minor damage can occur in fragile buildings (Caltrans 1998).

Noise Sources and Receptors

The noise environment is affected by geothermal resource operations in The Geysers geothermal field. Some of the noise sources associated with geothermal operations are relatively steady (e.g., cooling towers), while others are intermittent, but very intrusive (e.g., steam blowdowns). Wells PS-31 and P-32 are 2 miles from the Geysers 11 power plant and 2.5 miles from the Aidlin 1 power plant. The nearest operating well pad is located 1.5 miles away from PS-31 and P-32.

Table 3.7-1: Definition of Acoustical Terms Used in this Report

Terms	Definitions
Decibel, dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e.g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period. The hourly L_{eq} used for this report is denoted as dBA $L_{eq[h]}$.
Day/Night Noise Level, L_{dn}	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content, as well as the prevailing ambient noise level.

SOURCE: Caltrans 1998

Noise sources in the immediate vicinity of the proposed project area are typical to a rural landscape. Ambient noise is dominated by the natural setting and the baseline noise setting is similar to that found in a quiet rural area, between 30 to 40 dBA.

The project site is located within a previously developed and privately held geothermal area. The nearest potential sensitive receptor to project noise, which is a residence, is located 2 miles away from the proposed project area.

The source of ground-borne vibration in The Geysers is predominantly from heavy equipment usage.

Noise Standards and Policies

Several federal government agencies and states have developed guidelines regarding the types of land uses that are acceptable within noise-impacted areas. Where state guidelines are unavailable, local governments normally rely on the federal standards.

Sonoma County has identified geothermal development as a specific source of noise and has set a noise limit of 65 dBA at the exterior property line of any affected residential or sensitive land use. Noise standards are further established through the Use Permit process for individual geothermal development projects (Sonoma County 2008b). Calpine obtained a Use Permit from Sonoma County for the Wildhorse Development Project. The proposed project falls within the Wildhorse Development Project area.

3.7.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Noise Generation

General construction noise would result from the use of heavy equipment for construction of the SRGRP pipeline and re-grading the existing well pad. Maximum noise levels generated by construction activities typically range from about 85 to 90 dBA at a distance of 50 feet. Typical hourly average construction noise levels are about 10 dBA less than the maximum during busy construction periods (e.g., while earth moving equipment is operating). Table 3.7-2 lists the estimated maximum construction noise that may be heard at varying distances from the project activity. The nearest sensitive receptor is 2 miles away (from the pipeline and 2.75 miles away from the well pad).

Construction of the SRGRP pipeline and re-grading of the well pad would only occur during typical working hours. Maximum noise heard by the nearest residence would fall within a range compatible with a residential setting, which is approximately 49 to 60 dBA, with hourly averages from about 39 to 50 dBA. Noise generation would be below the acceptable range for daytime hours at the residence (acceptable noise range for daytime is 50 to 70 dBA) (Sonoma County 2008b). Construction would not occur during the nighttime.

Table 3.7-2: Estimated Noise Heard from Construction Activities

Distance from Project Site	Estimated Noise Heard from Construction Activities
100 feet	85 to 90 dBA
1,600 feet	60 to 65 dBA
3,200 feet	55 to 60 dBA
~10,500 feet (2 miles, nearest residence)	45 to 50 dBA

SOURCE: RMT Inc 2009

The conditions of the Use Permit for the Wildhorse Development Project would be implemented for the proposed project, as applicable. These conditions include measures that require noise to be controlled in accordance with the standards set in the Noise Element of the Sonoma County General Plan. The project also includes measures to address noise complaints. If investigation of noise complaints indicates that the appropriate noise standard levels have been or may be exceeded, Calpine would install, at their expense, additional professionally designed noise control measure(s).

Construction truck traffic, including haul and delivery trucks, would contribute to roadside noise levels; however, the number of truck trips per day on the private road used to access the sitewould be relatively few, and the duration that any one road would be used for construction purposes would be brief and not significantly adverse.

Vibration

Construction activities (e.g., ground-disturbing activities, including re-grading and the use of heavy construction equipment) may generate temporary localized ground-borne vibration. Construction activities would only occur during daytime hours and would result in short-term (i.e., no more than one or two days) impacts from vibration. Vibration attenuates quickly over distance. No buildings or structures are located within an area that would be affected by project-related vibration. Impacts from vibration would not be adverse.

Well Bore Modifications

Noise from re-opening and modifying the existing geothermal wells would have the most effect, as drilling would occur 24 hours per day, 7 days per week. Noise impacts from drilling would be temporary, lasting up to one month for completion of each well. The closest sensitive receptor is 2.75 miles away from the well pad. The loudest noise source while drilling a well is typically the noise emitted from air compressors (used while drilling with air). Air compressors can generate noise levels up to 85 dBA at 100 feet. Occasionally, wells are allowed to vent at full pressure for several hours to prevent the buildup of condensate. Because this operation is not usually muffled, noise levels of about 118 dBA can be produced. Well blowouts, generally caused by equipment strength being insufficient to withstand the steam pressure, can also cause noise levels similar to venting. Both of these events are very rare, especially the well blowout, which is an uncontrolled flow event.

Table 3.7-3 shows the typical noise from various drilling activities at varying distances, without the use of abatement measures.

Despite the temporary nature of the drilling, it could generate exterior noise from 85 dBA, at 100 feet; however, no noise receptors are located within 100 feet of the well pad. The closest sensitive receptor to drilling activities is located 2.75 miles from the well pad. Due to the great distance and the intervening topography of the surrounding area, drilling noise would attenuate to an acceptable level (~42 dBA), similar to a quiet suburban setting, at the closest residences. Unabated venting would generate more noise, about 75 dBA at the nearest residence. This noise may be less due to intervening topography. Venting noise would only occur for relatively short periods of

Table 3.7-3: Typical Noise from Geothermal Drilling Activities (dBA) Without Abatement

Activity	100 ft.	200 ft.	500 ft.	1,000 ft.	2,000 ft.	5,000 ft.	*14,520 ft.
Well drilling (include use of air compressors)	85	79	71	65	59	51	42
Steam venting or well blowouts	118	112	104	98	92	84	75

Notes:
Identified noise levels are given for various distances from a proposed noise-generating source. These noise levels do not account for the topographical barriers throughout the project vicinity, which may absorb or deflect sound waves, thereby reducing noise levels.

*14,520 feet is 2.75 miles, the distance from the well pad to the nearest residence.

SOURCE: HIll and Phelps 1980; CEGC 1994; RMT Inc 2009

time (hours); however, unabated could exceed the acceptable noise range for daytime of 50 to 70 dBA at the nearest residence (Sonoma County 2008b).

Adverse effects would be reduced through installation of temporary noise mitigation measures associated with the drill rig motors and air compressors, as described in the County Use Permit in order to minimize noise. With abatement, venting noise would be within the acceptable range and adverse effects would not occur. Additional equipment such as the mufflers and bleed valves would also be implemented to minimize noise impacts associated with drilling activities. Calpine would also accept and work to remedy any noise complaints.

Vibration

Vibration associated with ground drilling activities and well modifications could generate maximum vibration levels up to 103 to 104 VdB at 25 feet; however, vibration levels would attenuate to an indiscernible level due to the intervening distance between the project area and the nearest sensitive receptor and would not be adverse.

Stimulation

The stimulation phase of the project would involve the continuous flow of water from the newly constructed SRGRP pipeline to the re-opened wells at varying rates. An injection program would be designed to study the response of pre-existing fractures in the HTZ varying pumping rates. Stimulation would require some steam venting; however, venting would only occur occasionally for short periods of time (8 hours). Noise would be heard by the nearest residences during venting; however, venting would only occur for 8 hour periods once every 12 months. Noise could be as much as 75 dBA at the nearest residence during venting and could temporarily exceed County standards. If noise complaints are received, Calpine would implement measures to reduce noise during venting such as through installation of a noise barrier around the pad.

Noise impacts at all other times during this phase would be negligible and would not exceed County standards or stipulations set forth in the project Use Permit. No vibration impacts would occur.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects from noise would be similar to those described for the stimulation phase. If noise complaints are received, Calpine would implement measures to reduce noise during venting such as through installation of a noise barrier around the pad.

Monitoring and modeling techniques would be used to analyze data collected from well logging and testing. Monitoring would be continuously performed; however, noise levels would be similar to ambient conditions. Monitoring would not require the presence of any additional noise-generating equipment and no significant noise would be generated. No vibration impacts would occur.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its noise impacts could occur anyway.

3.8 Visual Resources

3.8.1 AFFECTED ENVIRONMENT

Regional Visual Setting

The Geysers are located within the Mayacmas Mountains, which are part of the Inner Coast Ranges of the California Coast Range, in Sonoma and Lake Counties. The predominant visual characteristic of the project region is rugged mountains with elevation ranges up to approximately 5,000 feet (Sonoma County 2008b). The rugged natural landscape is regularly disrupted in the region by power plants, steam collection lines, roads, cut and fill slopes, and other features of the extensive geothermal development.

Local Visual Setting

Project Area

The proposed project area is located at an elevation of approximately 2,100 feet and is surrounded by hills and mountains covered by a mixture of pine and oak forests with grassy groundcover. Visibility in the region is good, although precipitation and localized topography can all reduce regional visibility.

Viewsheds

A viewshed is an area that can be seen from a given vantage point and viewing direction. A viewshed is composed of foreground items (items closer to the viewer) that are seen in detail and background items (items at some distance from the viewer) that frame the view. The area in between is the mid-ground. The viewshed changes as a person moves along a roadway (a view corridor), with the foreground items changing rapidly and the background items remaining fairly consistent for a long period of time.

The viewshed at the project site is shaped by the regional features in the background (i.e., Ottoboni Ridge to the south-southeast, Cobb Mountain to the east) and local land uses in the foreground. The viewshed at the project site includes mountain ranges in the background and the existing unpaved roads and well pads in the foreground and mid-ground. The background of the viewshed is more aesthetically pleasing than the foreground and mid-ground in the project area.

Figure 3.8-1 depicts views of the project site and region.

Sensitive Receptors

The closest potential sensitive receptor in the proposed project area is located 2 miles from the proposed pipeline. Viewer sensitivity would be the highest for residents at elevations above the project area, in the surrounding hills found throughout The Geysers. The site is not readily visible from many other locations in the region due to lack of access to the general public (i.e., few public roads) and intervening topography.

3.8.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

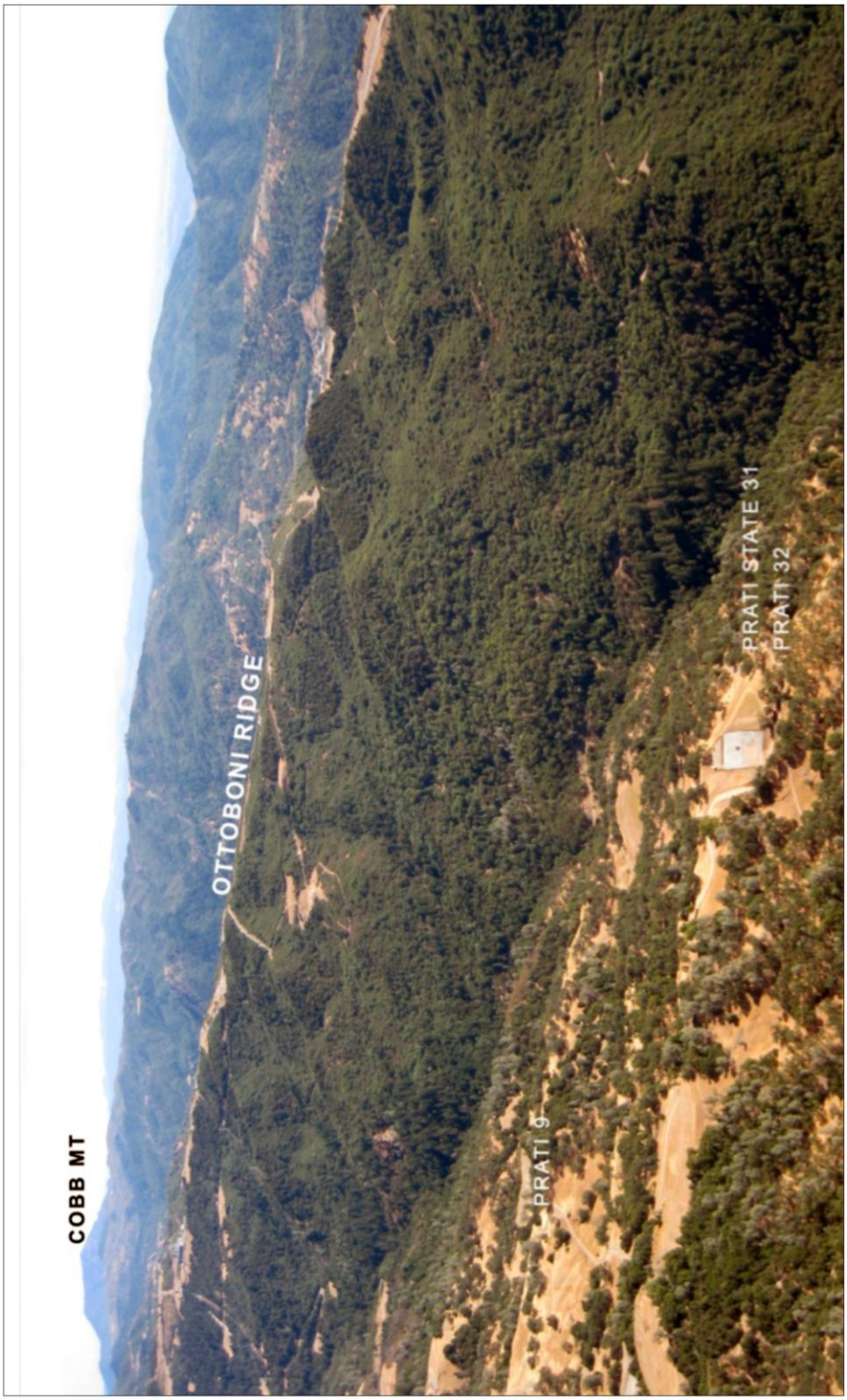
Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. Visual impacts from construction activities would result from:

- Views of construction equipment and facilities
- Views of disturbed ground during well pad preparation and construction of the SRGRP pipeline
- Views of the SRGRP pipeline spur

Preparation of the well pad and construction of the 1-mile long SRGRP pipeline spur would create short term visual impacts from the presence of construction equipment and ground disturbing activities. All ground disturbing activities would take place on previously disturbed areas.

Temporary visual impacts from construction would not be an issue because most of the viewshed from the project area is either private land and/or areas under controlled access. Few close-in view opportunities are available to the public (residents and visitors), whose viewing opportunities are

Figure 3.8-1: Viewshed in Project Region Looking South, Southeast (September 2009)



SOURCE: Calpine 2009

mainly afforded from Highway 175. These are distant views of the project area, and the site cannot be directly seen from any vantage points along the highway. The mountainous topography and lack of through roads preclude all but distant views of the project area.

The SRGRP pipeline spur would be painted in earth-tone colors if any segment is visible to the public.

Well Bore Modifications

Visual impacts from well bore modifications could result from:

- Views of drilling equipment and facilities on the re-established well pad
- View of the 135 foot tall drill rig for approximately 30 days
- View of steam plumes during well re-drilling
- Glare from lighting on the drill rig

The drill rig could be visible to surrounding land users, including distant residents. The drill rig would be visible from higher elevations, but would not interrupt the scenic background views of the surrounding hills. Drilling activities are anticipated to take approximately 30 days to complete and visual impacts from the presence of the drill rig and associated equipment would be temporary and would not be adverse. Steam plumes from the drilling could also be visible, but would not be large enough to block or obstruct background views. Drill rigs and steam plumes are generally in character with geothermal development in the project region. The remainder of the well equipment for drilling would blend into the foreground where it would not be visible to receptors (i.e., residents) due to distance.

Re-drilling would occur 24 hours a day, 7 days a week for about 1 month per well. Lighting would be required on the drill rig during nighttime drilling. Lighting could generate glare and affect the nighttime sky, due to the relative remoteness of the project; however, the project includes requirements for rig lights to be shaded and focused downwards to reduce nighttime glare from the well pads during re-drilling operations.

Visual impacts from well bore modifications of the EGS wells would not be considered adverse.

Stimulation

Stimulation is the process of injecting water into the HTZ through the new SRGRP pipeline spur and into the injection system at the well heads. This process would not be visible. Steam plumes may be visible from the well heads if venting is required during stimulation, and may extend tens of feet into the air. Given the distance of the well pad from any urban development and the surrounding topography, steam plumes would not obstruct background views for any nearby viewers. Impacts to visual resources from the steam plume would not be considered adverse and are generally in character with geothermal development in the project area.

Temporary lighting during emergencies may be required on the well pads but would be shielded, directed downward, and only on for short periods of time, so as to avoid adverse effects.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects to visual resources would be similar to those described for the stimulation phase and would not be adverse. There would be no new visual impacts from data collection, assessment, and monitoring. Equipment used to monitor would be existing and use of these systems would not be visible from receptors due to their distance and the small size of monitoring equipment.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact could occur anyway.

3.9 Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment

3.9.1 AFFECTED ENVIRONMENT

Hazardous Materials

Hazardous materials are those substances that, because of their physical, chemical, or other characteristics, may pose a risk of endangering human health or safety or of endangering the environment (California Health and Safety Code Section 25260). Types of hazardous materials include petroleum hydrocarbons, pesticides, and volatile organic compounds.

Two superfund sites are located in Sonoma County, the MGM Brakes site near Cloverdale and the Sola Optical USA site located near Petaluma. Both sites are remediated and are located far from the proposed project site (EPA 2009c). A review of the state Cortese List shows that neither the project area nor the immediate area around it is a hazardous materials release site per Government Code § 65962.5.

The project area is located in a geothermal resource area that has naturally occurring hazardous substances found in the soils, groundwater, and geothermal steam. These hazardous substances include asbestos (from serpentinite rock) and heavy metals such as mercury, sulfur, and arsenic. Other hazardous materials such as hydrocarbon fuels are used regularly as part of geothermal operations in the project region.

Waste Management

Waste Characterization

Waste must be managed and disposed of in accordance with its hazard classification. Waste can be classified as either hazardous or non-hazardous. Hazardous wastes are defined by one of three types, including:

- Resource Conservation and Recovery Act (RCRA) hazardous waste
- Non-RCRA hazardous waste
- Universal waste

Wastes classified as "hazardous" under RCRA are listed on one of the RCRA hazardous waste lists (e.g., F-list, K-list, P-list, or U-list). These wastes meet federal definitions as having one of the hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, and/or is a mixed hazardous waste as defined in 40 CFR Part 261.

Non-RCRA hazardous wastes are wastes that have hazardous characteristics, but do not meet the federal definition of a hazardous waste. In California, waste oils and wastes containing or contaminated with waste oils are considered to be a non-RCRA hazardous waste (Title 22, CCR §66261.101).

Universal wastes are materials that are hazardous upon disposal but pose a lower risk to people and the environment than other hazardous wastes (40 CFR Part 273.9 and 22 CCR § 66273.1). Generators of waste are responsible for determining whether or not the wastes they generate are classified as hazardous or not pursuant to federal and California requirements.

Waste Disposal Facilities

Waste disposal facilities in the project region include Calpine's GDMACDA Waste Management Unit and the Super Sump Solid Waste Management Facility, which is also owned and operated by Calpine in The Geysers. These facilities are permitted by the RWQCB North Coast Region and the Sonoma County Health Department to accept non-hazardous drilling wastes. Hazardous material would be transported off-site to the Kettleman Hills Landfill, managed by Chemical Waste Management, a Class I, II, and III disposal facility in Kettleman Hills, CA, which is permitted to accept hazardous wastes. (Chemical Waste Management 2008). The landfill is permitted to accept 8,000 tons of waste per day, with a remaining landfill capacity of 6 million cubic yards (CH2M HILL 2008).

Human Health and Safety

Safety Training

Safety practices and training are required for all workers at the site. Work currently performed by Calpine in other areas of The Geysers involves hazards that can result in accidents, serious injury, acute exposures, and chronic health exposures. Work that involves hazards includes operation of process equipment and heavy machinery, geothermal related work, and working with hazardous materials. Protection measures are implemented by Calpine to eliminate these hazards or

minimize the risks and include employee training on the use of procedural controls and use of protective equipment.

Emergency Response

Calpine's workers are trained on emergency response procedures involving unexpected releases and other emergency situations that may occur at the facility. Emergency response procedures are provided in Calpine's Hazardous Material Business Plans (HMBP) and SPCC Plans,. In addition, local emergency services, such as CalFire emergency services, located in Cobb and Middletown, the Sonoma County Department of Emergency Services and the Coastal Valleys Emergency Medical Services, are available to provide outside emergency response as needed (Coastal Valleys EMS Agency 2008).

Risk Assessment

In September 2006, Sonoma County Department Emergency Services prepared a Hazard Mitigation Plan. The plan analyses risks to human health and property damage from earthquakes, landslides, floods, and wildland fires. The plan serves as a guide for government officials as they determine how best to reduce impacts of these hazards.

The risk of each hazard is listed in Table 3.9-1. The plan explains how the total hazard risk was determined.

The project area is located within wildland areas that may contain substantial forest fire risks and hazards. The project region experiences long seasonal periods without rain, making the area particularly vulnerable to wild fires. Calpine has fire prevention and control procedures in place to address the potential occurrence of a fire at existing facilities.

CalFire provides service in unincorporated areas such as the project area. CalFire has a station in the nearby town of Cobb (approximately 8.8 miles from the project site).

Table 3.9-1: Relative Risk of Hazards for Lake County

Hazard	History	Frequency	Probability	Impact
Earthquake	Yes	Low	High	High
Flood	Yes	High	High	High
Landslide	Yes	Medium	Medium	High
Severe Winter Storm	Yes	Medium	Medium	Medium
Wildfire	Yes	High	High	High
Windstorm	No	Low	Low	Low
Drought	Yes	Low	Low	Medium

SOURCE: Sonoma County 2009

3.9.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Hazardous Materials

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. Some hazardous materials from project-related activities (i.e., fuels, oils) would be present on-site during construction activities. The likelihood of substantial spills and discharges in this area would be low due to the limited amount of chemicals that would be used or transported as part of the proposed project. Hazardous chemicals that may be transported would include fuels, oils, and lubricants and would be used during construction. Discharge of oils or petroleum products could occur from equipment leakage but would involve a very small volume.

Contamination of stormwater run-off at the drilling pad would be minimized through drainage and collection of run-off in a reserve tank. Contamination along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater. Calpine would implement a SPCC on-site to contain incidental drips and/or spills. All hazardous material storage would be surrounded by containment berms.

Asbestiform minerals may be found naturally in the soils, these could become airborne in dust particles during construction and re-grading. The Asbestos Air Toxic Control Measure for construction, grading, quarrying, and surface mining as approved by CARB would be implemented. Watering to reduce dust emissions would also help to minimize release of asbestiform minerals into the air.

Waste Management

Sonoma County has a solid waste management program in place that provides solid waste collection and disposal services for the entire County. The program can accommodate the permitted collection and disposal of the small amount of construction waste that would result from the proposed project.

Hazardous wastes such as hydrocarbon wastes or asbestos laden wastes would be disposed of at the Kettleman Hills Landfill, managed by Chemical Waste Management and permitted to accept hazardous wastes, in Kettleman Hills, California (Sonoma County 2005). Adverse effects related to waste management would not occur.

Human Health and Safety

Construction could generate considerable noise. Workers would wear hearing protection and other PPE as required by OSHA to prevent injuries.

Construction workers would comply with OSHA and CalOSHA asbestos removal worker requirements whenever serpentine rock containing over one percent asbestos is being excavated. OSHA asbestos worker safety regulations are found in 29 CFR 1910. CalOSHA regulations are found in 8 CCR. The regulations require monitoring airborne asbestos fiber levels, worker safety

training, and the use of PPE by workers when asbestos levels exceed 0.2 asbestos fibers per cubic centimeter of ambient air.

Exposure to other hazardous materials and wastes would be minimized through proper handling and training. Adverse effects to human health from construction activities would not occur.

Risk Assessment

The most substantial risk during construction activities is fire. The potential for fire is high because the project is located within undeveloped hillsides dominated by dry vegetation. Fire hazards would be minimized through the maintenance of an on-site water tank to put out any potential fires. Other measures would also be implemented as listed below.

- Fire extinguishers and shovels would be available on-site
- All brush build-up around mufflers, radiators, and other engine parts would be avoided; periodic checks would be conducted to prevent this build-up
- Smoking would only be allowed in designated smoking areas; all cigarette butts would be placed in appropriate containers and not thrown on the ground or out windows of vehicles
- Cooking, campfires, or fires of any kind would not be allowed
- Portable generators used in the project area would be required to have spark arresters

Calpine has health and safety procedures that address prevention of fires in The Geysers. Each of these plans, applicable to the proposed project, would be implemented to minimize adverse effects associated with fire hazards:

- ***Fire Prevention Plan (HSP-60):*** This plan identifies potential fire hazards; flammable materials; potential ignition sources; control, handling, and storage methods; and training requirements associated with geothermal operations that are applicable to all Calpine personnel and contract employees working in The Geysers.
- ***Hot Work Permit Procedure (No. 145)***: This plan sets forth a permit system for controlling primary work-related sources of fire and the potential fire hazards associated with Hot Work (i.e., welding, soldering, grinding, or use of an open flame) applicable to all Calpine personnel and contract employees working in The Geysers.
- ***The Calpine Geysers Emergency Preparedness and Response Plan:*** This plan contains the Response to Wild Land Fire section that provides procedures to be taken by Calpine employees to fight incipient fires and/or isolate and control a wild land fire until outside help arrives.

Well Bore Modifications

Hazardous Materials

Re-drilling would involve use of hazardous materials. These materials would include, but would not be limited to, drilling additives and mud, diesel fuel, lubricants, solvents, oil, equipment/vehicle emissions, and geothermal fluids. Use of these materials would be in compliance with all local, state, and federal regulations regarding the use, transport, storage, and

disposal of hazardous materials and wastes. Calpine would prepare a SPCC to prevent adverse impacts to the environment from release of hazardous materials.

Well blowouts and pipeline failures are rare occurrences during well drilling and can result in the release of drilling additives and fluids, as well as H_2S gas (see *Section 3.2 Air Quality* for more information on hydrogen sulfide) from the geothermal resource. Blowouts may also result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants.

Calpine has an existing detailed blowout prevention plan to minimize adverse effects associated with potential blowouts. (Appendix F). Measures include:

- Performing regular maintenance of wellhead, including corrosion control and inspection, pressure monitoring, and use of blowout prevention equipment such as shutoff valves;
- Preparing an emergency response plan for well blowout, including measures for containment of geothermal fluid spills;
- Preparing a contingency plan for hydrogen sulfide release events, including all necessary aspects from evacuation to resumption of normal operations;
- Providing workers with a fact sheet about the potential human health and safety impacts from exposure to liquids and gases from the production well during a blowout.

Well re-drilling would employ sumpless drilling rig operations. The drilling process may encounter serpentine-containing rocks. Dust emissions from venting steam during testing would be reduced by injecting water into the blooie line.

With implementation of the blowout prevention plan and standard safety precautions, adverse impacts from hazardous material exposure during well bore modification would be minimized.

Waste Management

Wastes generated during drilling would include solids (rock bits), mud, and cement. The entire tank and solids removal system during re-drilling would be enclosed within a berm, as would the rig substructure and auxiliary equipment. Mud or aerated mud is proposed for initial drilling operations. When mud drilling is finished, all liquid mud and solids would be collected and hauled to the geothermal drilling waste solids disposal facility in The Geysers. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit. No adverse effects from waste handling and management during well bore modifications would occur.

Human Health and Safety

Re-drilling would generate considerable noise. Workers would wear hearing protection and other PPE to prevent injuries, as required by OSHA.

Steam encountered during drilling and testing would likely contain H_2S. H_2S is a colorless, non-condensable gas with a characteristic "rotten egg" odor. H_2S is toxic at certain levels and can cause negative human and animal health effects. Exposure to H_2S can cause dizziness, headache, and

nausea at 50 ppm and death from respiratory paralysis at 1,000 ppm. Nuisance odor is of primary public concern since this distinctive odor can be easily detected at concentrations far below levels of health concern. Odor is detectable from about 0.008 ppm. Re-drilling would include H_2S abatement and implementation of the ATC and temporary PTO conditions from the NSCAPCD, such that workers would not be exposed to significant quantities of H_2S.

Exposure to asbestiform minerals would be minimal during re-drilling and testing due to abatement of dust by injecting water into the blooie line.

Exposure to other hazardous materials and wastes would be minimized through proper handling and training. Hazards related to blowouts and other emergencies would be minimized through implementation of the blowout prevention plan. Effects to human health from re-drilling activities would not be adverse with implementation of these measures.

Risk Management

Fire risks would still exist during the well bore modification phase; however, risks would be slightly less than for construction because all re-drilling activities would occur on the well pad.

Fire prevention measures identified for construction activities would be implemented during well bore modification in order to avoid adverse effects.

Stimulation

Stimulation is the process of injecting water into the HTZ through the new SRGRP pipeline spur and into the injection system at the well heads. The only hazard potential during stimulation would be H_2S emissions from venting of steam. Abatement and implementation of the temporary PTO conditions would minimize hazards from stimulation. No wastes would be generated. Microseimic and induced seimic hazards are addressed in *Section 3.3 Geology*.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Similar to stimulation, H2S emissions from vented steam would be the only hazard. Abatement and implementation of the temporary PTO conditions would minimize hazards from stimulation.

Existing equipment would be used for monitoring. No nuclear logging equipment or other equipment would be used and exposure to hazards would be minimal during the monitoring and evaluation phase of the project. No wastes would be generated. Adverse effects related to hazardous materials, waste management, health and safety, and risk assessment would not occur.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact could occur anyway.

4: Cumulative Effects

4.1 Introduction

NEPA requires that agencies consider the cumulative impacts of a proposed federal action or project. NEPA regulations define a cumulative effect as the effect on the environment that results from the incremental effect of the action when added to the effects of other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions and regardless of land ownership on which the other actions occur. An individual action when considered alone may not have a significant effect, but when its effects are considered in sum with the effects of other past, present, and reasonably foreseeable future actions, the effects may be significant (40 CFR 1508.7 and 1508.8, and FSH 1909.15 Section 15.1).

This cumulative impact analysis considers impacts of the proposed action and other projects that have been proposed, or are reasonably foreseeable to take place in the vicinity of the proposed action. The primary activities considered in the analysis of cumulative impacts are other geothermal projects and other activities in the project vicinity that may occur at the same time as the proposed action.

The geographic area considered for cumulative impacts is generally considered to be a 10-mile radius from the proposed project area, although boundaries of analysis are dependent upon the type of impact to be assessed and the extent of the proposed project's impacts.

The effects of construction activities, well bore modifications, stimulation, and ongoing monitoring and evaluation of the proposed project are described in Chapter 3 of this document.

4.2 Other Projects in the Area

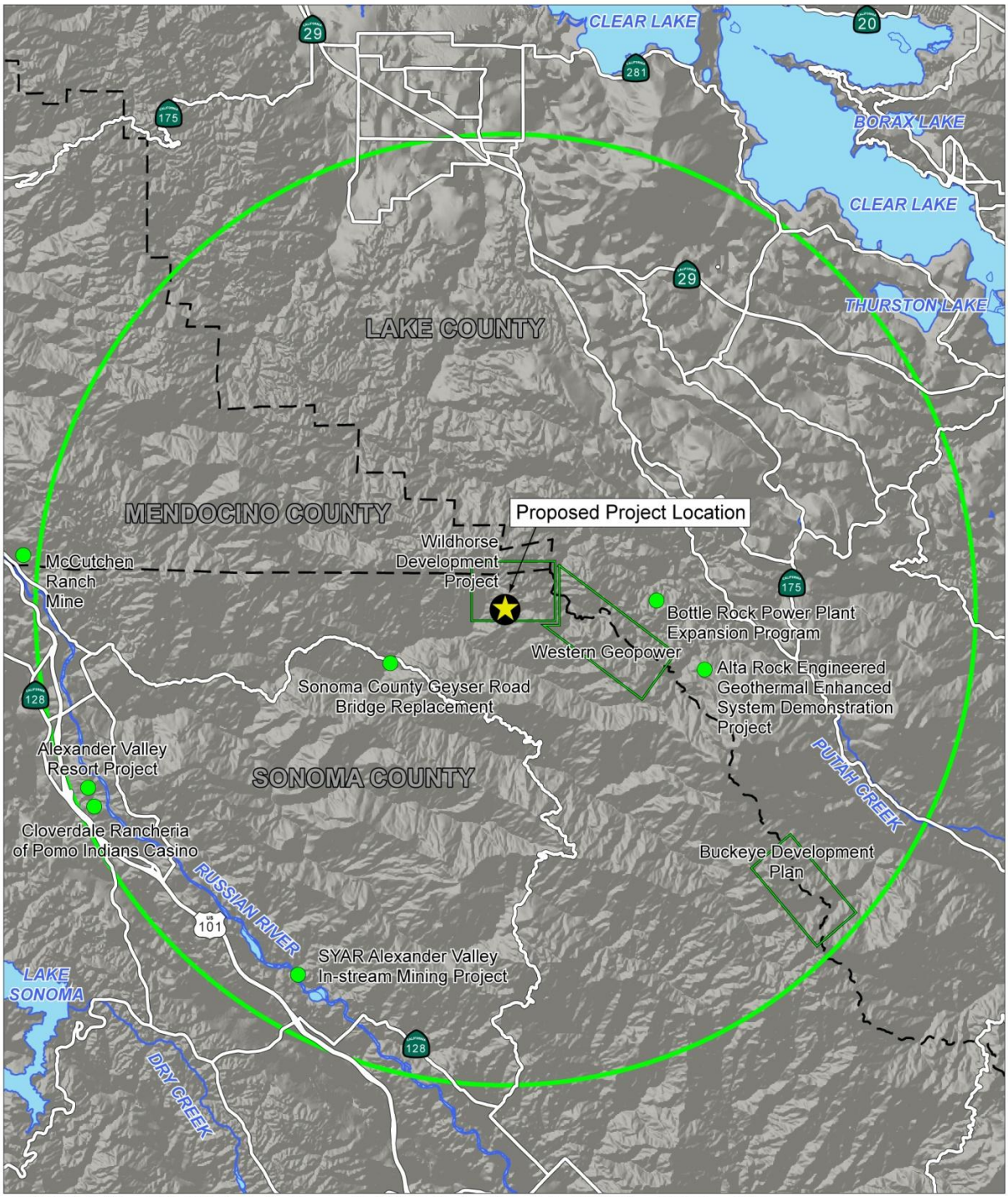
This section provides a brief discussion of past, present, and reasonably foreseeable future projects near the proposed project that could have some potential to result in cumulative impacts. Several upcoming renewable energy projects, pending approval and funding, have been identified within a 10-mile radius from the proposed project area as shown in Figure 4.2-1.

Cumulative impacts are not expected with implementation of the proposed environmental protection measures.

4.2.1 WILDHORSE DEVELOPMENT PROJECT

The Calpine Geysers Power Company is proposing to drill up to 58 geothermal wells from up to 14 existing well pads. This project would include the construction of up to 29,000 feet of access corridors for steam pipelines, roads, associated electrical distribution (21kV), as well as other appurtenant facilities to connect the producing and injection wells to existing geothermal infrastructure and power plants. The proposed project falls within this Wildhorse Development Project.

Figure 4.2-1: Location of Projects Considered in the Cumulative Analysis



SOURCE: Calpine 2009, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 2009, and RMT Inc. 2009

LEGEND

- Project Location
- U.S. Highway
- State Route
- Other Projects in the Area
- 10 Mile Project Buffer

N W E S

0 1 2 4 6 8 Miles

RMT • ENVIRONMENT • ENERGY • ENGINEERING

4.2.2 ALTA ROCK ENGINEERED GEOTHERMAL ENHANCED SYSTEM DEMONSTRATION PROJECT

The Alta Rock Engineered Geothermal Enhanced System Demonstration Project is located in the southeastern portion of The Geysers, west of Middletown. The project proposes to create additional sources of geothermal power by deepening an existing injection well and creating a new engineered steam reservoir system. A new production well would be drilled to intersect and utilize the new steam reservoir. The Alta Rock EGS Demo project is located approximately 10 miles from the proposed EGS project.

4.2.3 BOTTLE ROCK POWER PLANT EXPANSION PROGRAM

Bottle Rock Power is planning to modify its existing Bottle Rock Power Plant with the development of a new steam field on the Bottle Rock Power GeoResource Leasehold. The project would entail adding two well pads, drilling up to 24 new wells, constructing an insulated steam gathering pipeline and a condensate injection pipeline, and establishing a new access road. The project would increase the power output of the plant from a maximum of 17 MW to approximately 55 MW. No significant changes would be made to the power plant itself or the capacity of the electrical transmission system in the project area. The Bottle Rock Power project is located approximately 9.5 miles from Calpine's proposed EGS project.

4.2.4 SONOMA COUNTY GEYSER ROAD BRIDGE REPLACEMENT

The Sonoma County Department of Transportation and Public Works has proposed a project to replace the existing one-lane bridge on Geysers Road over Big Sulphur Creek with a new two-lane bridge. This project is located approximately 5 miles from the proposed project and has not yet undergone environmental review and no date for construction has been proposed.

4.2.5 SYAR ALEXANDER VALLEY IN-STREAM MINING PROJECT

Syar Industries is proposing a project to gravel mine a 6-mile stretch of the Russian River near the intersection of Gill Creek and the Jimtown Bridge, approximately 10 miles from the proposed project. No additional infrastructure would be required for the in-stream mining project. Mining equipment would be allowed to gravel mine no more than one bar at a time from April to October. Sonoma County would evaluate the project on a yearly basis to determine if mining operations can resume the following year under the conditions set forth in the project Use Permit. This project may also include an amendment to Sonoma County's Aggregate Resource Management Plan to extend the 10 year term for mining permits to 15 years. Mining operations could begin as soon as 2010. Additional restoration measures determined by governing agencies may be required as mitigation for this project and could include actions such as reconnecting Gill Creek to Russian River.

4.2.6 CLOVERDALE RANCHERIA OF POMO INDIANS CASINO

The Cloverdale Rancheria of Pomo Indians has acquired 79 acres of land next to Highway 101, immediately southeast of the Cloverdale city limits. The project is currently undergoing environmental review for a resort casino with a main hall containing 2,000 slot machines and 45 gaming tables, a 244-room hotel, a convention center, entertainment center, and restaurant. The project is approximately 10 miles from the proposed project.

4.2.7 ALEXANDER VALLEY RESORT PROJECT

Tyris Corporation has proposed a 254-acre development project located approximately 10 miles from the proposed project. Environmental review and a Specific Plan have been completed and approved by the City of Cloverdale. The project includes an 18-hole golf course with a driving range and clubhouse, a 150-room resort hotel with conference facilities, spa, and restaurant, and a 2.4 acre commercial site approved for the development of a wine tasting facility and restaurant. Additional housing has also been proposed and includes:

- 40 fractional ownership villas
- 105 detached single family homes
- 25 estate homes

Construction is estimated to begin in 2010. The project is located approximately 10 miles from the proposed project.

4.2.8 WESTERN GEOPOWER

Western GeoPower is proposing to construct a 38.5 MW geothermal power plant including three new buildings (an electrical/control building, an operator hygiene building, and a fire pump building), a 200,000 gallon water tank for fire protection, a cooling tower, and nine production and two injection wells. The project includes the construction of a steam transmission and electrical switchyard to connect to PG&E's existing 115 kV power line. The project is located at the site of a former PG&E power plant; therefore, most of the infrastructure required for the project is already in place. No major grading would be required because existing roads, well pads, and transmission line and power plant siting would be used.

4.2.9 BUCKEYE DEVELOPMENT PROJECT

Calpine's the Geysers Power Company is proposing to drill 21 geothermal wells on 5 new drill pads, requiring the development of approximately ten acres and 2, 500 feet of new roads. Calpine would construct 6,750 feet of new access corridors for the pipeline and similar geothermal infrastructure. The steam field development would connect with existing power plants or be used for general resource development including recharging the geothermal resource with re-injection.

4.2.10 MCCUTCHEN RANCH MINE

The McCutchen Ranch is an operating hard rock quarry operating for the last decade under the conditions of a Use Permit from Mendocino County. The mine is located near the southern border of the Mendocino County, approximately 10 miles from the proposed project area.

4.3 Cumulative Effects

4.3.1 OVERVIEW

The cumulative impacts of the proposed projects are described below. All defined environmental protection measures would reduce any potential impacts from the proposed action to less than significant levels.

Resources with the potential for cumulative impacts include:

- Air Resources
- Geology
- Biological Resources
- Water Resources
- Noise
- Visual Resources
- Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment

The proposed project could contribute to some overall cumulative impacts to these resources; however, none of these cumulative impacts would be significant with implementation of the proposed environmental protection measures.

4.3.2 PROPOSED ACTION

Air Quality

The proposed project would generate some emissions during construction, including H_2S emissions, particulate matter, and precursors to ozone. Sonoma County is in attainment for federal standards for PM_{10}.The entire North Coast Air Basin is currently designated as in nonattainment for the state 24-hour and annual average PM_{10} standards. The air basin is designated as unclassified for the state annual $PM_{2.5}$ standard because available data is insufficient to support a designation of in attainment or nonattainment (EPA 2009). The proposed project would generate some PM_{10} and $PM_{2.5}$. Cumulative impacts could occur if projects occurring simultaneously also produced enough particulate matter to exceed ambient air quality standards. Several projects within a 10 mile radius of the proposed project would involve ground disturbance. Some of these projects could overlap in the construction timeframe; however, they would occur over a 10 mile area. None of these projects would be expected to generate significant amounts of particulate matter and it is likely that measures would be enforced to reduce fugitive dust levels for each project. Cumulative impacts would not occur.

The proposed project could also generate some H_2S emissions, as would the other geothermal projects in the area. With abatement, the proposed project would not contribute to significantly adverse cumulative effects from H_2S emissions due to the small amount of emissions anticipated, the short timeframe of emissions (i.e., well drilling, testing, venting), and the distance to other projects.

Biological Resources

Cumulative impacts to biological resources would occur if the project, in relation to another or other projects, led to a substantial spread of invasive species or threatened the existence of a special status species or its habitat. The proposed project would not have adverse impacts on biological resources with the implementation of environmental protection measures including pre-construction surveys for avian species and raptors and the implementation of a SWPPP and BMPs.

All other projects in the region would be required to adhere to similar standards and regulations of Sonoma County (or Lake or Mendocino Counties), CEQA, and NEPA. This would include mitigating any potential impacts to biological resources. The proposed project would not result in any new ground disturbance in previously undisturbed areas; therefore, it would not contribute to any significant cumulative effects related to the spread of invasive species. Other projects could also impact avian species; however, given the large, undisturbed area between projects where birds could forage and breed without disturbance, and the measures incorporated into the project to protect nesting birds, adverse cumulative effects would not occur.

Geology

The IRWP EIR determined that injecting 25 million gallons per day of recycled water would increase the frequency of Modified Mercalli Intensity (MMI) V earthquakes at Cobb from 0.74 earthquakes per year to 1.15 earthquakes per year, a 55 percent increase, which was determined to be significant. Anderson Springs would experience a 45 percent increase, which was also determined to be significant under CEQA. The proposed project is a small part of the overall IRWP project. While the overall project was determined to cause a significant impact, the proposed project would not have an incrementally significant contribution to the overall effect.

The proposed project involves injection from 0.29 million gallons per day (1 percent of the total water from the IRWP) to as much as 1.15 million gallons per day (5 percent of the total water from the IRWP). This water would be injected as part of the overall IRWP project. The proposed project will move injection water into an area that is further away from communities, which may help to reduce the effects of induced seismicity on residents and community members. If the proposed project were not to occur, this water would be injected anyway as part of the IRWP and would likely be injected closer to the communities.

The Alta Rock and Bottle Rock project could also cause microseismic events. The proposed project would not generate any large-scale, damaging earthquakes, due to the nature of the project (low pressure injection to reopen existing fractures), distance from communities, and the depth of the injection related to the depth of deep earthquakes. Implementation of the Alta Rock project (or any of the other geothermal projects in The Geysers) would not change the potential for inducing large earthquakes from the proposed project. Areas such as Cobb and Anderson Springs could experience microseismic activity from all projects, but again, the proposed project would move the injection sites further away from these communities reducing the adverse effects.

Other projects in the region would not be expected to lead to aggregated impacts from other geologic hazards due to the distance between projects. With implementation of the environmental protection measures identified, the proposed project would not cause a significant cumulative impact.

Water Resources

The proposed project would not alter any surface water sources; therefore, it would not contribute to any potentially cumulative effects related to surface water hydrology in the project region.

The project would use some groundwater from Calpine entitlements; however, the groundwater system in the area is limited and not hydrologically connected to the groundwater in the other

project areas. Use of groundwater in the proposed project area would not compound with use or availability of groundwater in the other project areas and no cumulative effects would occur to groundwater quality, supply, or use. Calpine would be expected to coordinate groundwater use among its own projects.

Cumulative impacts would occur if water quality was seriously degraded due to a hazardous materials spill. The proposed project would be confined to a specific area and all spills during construction and/or operation would be contained and cleaned. The chance of a hazardous materials spill being compounded by any of the other projects in the area is unlikely. Cumulative impacts to water quality would not occur.

Noise

Cumulative impacts could occur if other noise is generated in the same area as the proposed project. The proposed project would increase noise in the region during drilling and construction; however drilling and construction would be temporary and proposed strategies, including notifying neighboring properties of noise effects and installing temporary noise protection measures associated with drill rig motors and air compressors, would prevent adverse impacts. The construction of several anticipated projects could occur at the same time as the proposed project; however, the distance between these projects and the topography would prevent cumulative noise effects.

Visual Resources

The proposed project would have temporary impacts on visual resources during construction; however, most construction would occur in foreground views and would not impact the more scenic background views. The construction activities and the drilling would not be within the same view shed as any of the other projects. Geothermal activities are very common in The Geysers and the appearance of drill rigs in the distance is not considered significantly adverse. The project would temporarily add one drill rig in the visual landscape for a 30 day period, per well, which would not be a significantly adverse contribution to a cumulative effect.

Hazardous Materials, Waste Handling, Health and Safety, and Risk Assessment

The project area is located in a geothermal resource area that has naturally occurring hazardous substances found in the soils, groundwater, and geothermal steam. These hazardous substances include asbestos (from serpentinite rock) and heavy metals such as mercury, sulfur, and arsenic. Other hazardous materials such as hydrocarbon fuels are used regularly as part of geothermal operations in the project region. Cumulative impacts would occur if projects in the same location caused the release or discharge of hazardous materials or substances in levels exceeding local, state, or federal health and safety standards. The proposed project is confined to a specific area and hazardous materials used during construction would be in compliance with all local, state, and federal regulations. All spills during construction and/or on-going monitoring would be contained and would not enter local waterways with the implementation of the proposed environmental protection measures. Hazardous materials spills would not be compounded by any other project in the area, as they would be subject to the same procedures and standards identified in *Section 3.9 Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment*.

Exposure to asbestiform minerals would be minimal during drilling and testing due to abatement of dust by injecting water into the blooie line. Hazards related to blowouts and other emergencies would be minimized through implementation of the blowout prevention plan. These effects are all localized to the project area and a short distance around the project area. Effects from hazardous materials and wastes would therefore not contribute to any cumulative effects.

Wastes would be properly disposed. Calpine has its own permitted facilities for disposal of drilling wastes; therefore, the project's wastes would not have a cumulative effect on collection facilities in the region that could be serving other projects. Hazardous wastes would go to the Kettleman Hills Landfill, which has more than sufficient capacity to serve all projects in the region.

The proposed project has some potential to cause forest fires. Other projects could also cause forest fires; however, due to the distance between projects, and the measures include in the proposed project to prevent fires, no cumulative increase in risk is expected due to the proposed project.

4.3.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts, including cumulative effects identified here, could occur anyway.

5: Irretrievable/Irreversible Commitment of Resources

This section describes the major irreversible and irretrievable commitments of resources that can be identified at the level of analysis conducted for this EA. A commitment of resources is irreversible when its primary or secondary impacts limit the future options for a resource or limit those factors that are renewable only over long periods of time. Examples of non-renewable resources are soils; minerals, including petroleum; and cultural resources.

An irretrievable commitment of resources refers to the use or consumption of a resource that is neither renewable nor recoverable for use by future generations. Examples of irretrievable resources are the loss of production, harvest, or recreational use of an area. While an action may result in the loss of a resource that is irretrievable, the action may be reversible. For instance, paving over farmland results in the irretrievable loss of harvests from that land; however, the parking lot could be removed and crops could be grown again. This action would be reversible.

The proposed project would require the irreversible and irretrievable commitment of construction materials. Construction water would be irretrievable and irreversible. The use of water from the SRGRP for injection would be an irretrievable irreversible commitment of reclaimed water; however, it may be retrieved as geothermal steam for energy production.

Injection could generate seismic activity; however, this is believed to be reversible through the cessation of activity on the EGS system.

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