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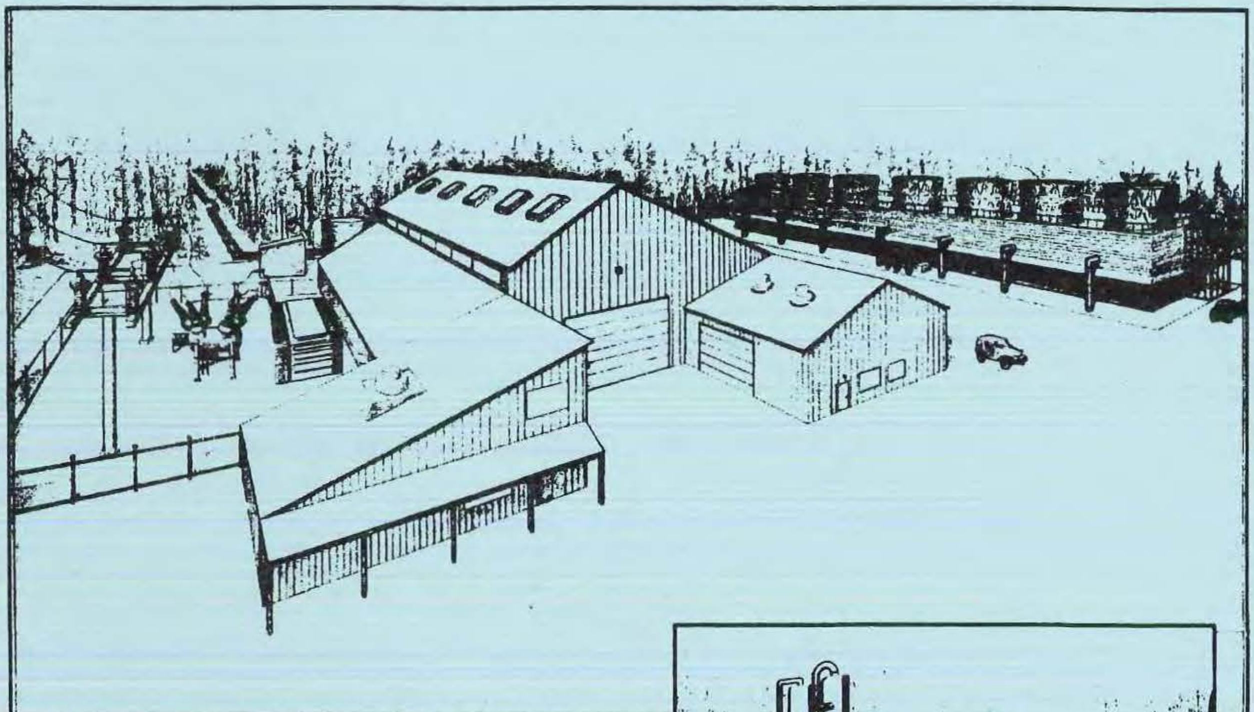
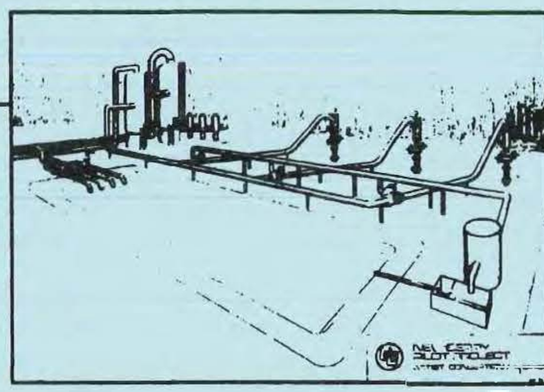
Newberry Geothermal Pilot Project

Final Environmental Impact Statement





CE Exploration Company of Portland, Oregon has submitted a proposal to build and operate a 33-megawatt geothermal power plant in the Deschutes National Forest in Central Oregon. This is the draft version of the environmental analysis of the proposed project, prepared by the U.S. Forest Service, the U.S. Bureau of Land Management, and Bonneville Power Administration.

U.S. Forest Service

Bonneville
POWER ADMINISTRATION

U.S. Bureau
of Land Management

FINAL ENVIRONMENTAL IMPACT STATEMENT
FOR
PROPOSED NEWBERRY GEOTHERMAL PILOT PROJECT

Deschutes National Forest
Deschutes County, Oregon
July 1994

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Abstract

CEE Exploration Company of Portland, Oregon proposes to build and operate a geothermal pilot project and supporting facilities capable of generating 33 megawatts of electric power in the Deschutes National Forest in central Oregon. The facilities would include a power plant, access roads, exploration and production wells, a power transmission line, and a switchyard. The project would consist of four distinct phases: exploration, development, utilization, and decommissioning. The project would be located on the west flank of Newberry Volcano on Federal geothermal leases.

This Environmental Impact Statement analyzes three alternatives for this proposed geothermal pilot project. Each alternative responds differently to the issues and concerns identified in the EIS process.

Alternative A is the proposal submitted by CEE. It includes a single power plant site, 14 well pads for drilling exploration and development wells, a transmission line, access roads and steam pipelines to bring the steam to the power plant.

Alternative B was developed to respond to the issues and provide siting flexibility to make the most efficient use of the geothermal resources while minimizing environmental effects. Many components are similar to those in Alternative A. Major differences are that it proposes different siting locations, a different transmission line route and design, and additional mitigation measures. Alternative B is the agencies' Preferred Alternative.

Alternative C is the No Action Alternative.

How This Environmental Impact Statement is Organized

Chapter 1.0 Purpose & Need and Background	Describes the need for Federal action, the agencies involved, and the decisions to be made. Provides background information on geothermal energy and describes the public scoping process and issues raised.
Chapter 2.0 Alternatives Including the Proposed Action	Discusses the range of alternatives, describes each alternative in detail, and summarizes comparison of action alternatives and effects.
Chapter 3.0 Affected Environment	Addresses aspects of the existing environment. This section is divided into a discussion of 14 different environmental parameters, for example: geology, cultural resources, and air quality.
Chapter 4.0 Effects of Implementing Each Alternative	Provides the analysis used for comparison of the alternatives and discusses the environmental consequences of the alternatives. This section follows the same order of the 14 aspects of the environment as Chapter 3.0.
Chapter 5.0 List of Preparers	Provides list of people who contributed, reviewed, and/or prepared the document.
Chapter 6.0 References Cited	Provides list of documents referenced to provide technical information.
Chapter 7.0 List of Agencies to Whom Copies of the EIS Were Sent	Provides list of agencies that were sent copies of the EIS.
Chapter 8.0 Acronyms & Glossary of Terms	Provides easy reference to abbreviations and technical terms used in the document.
Chapter 9.0 Index	Shows the page numbers of key issues and topics for quick reference.
Appendices	Present additional supporting technical information. Published separately.

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1.0
PURPOSE AND NEED AND BACKGROUND

1.1. INTRODUCTION

CE Exploration Company (CEE) of Portland, Oregon, submitted to the U.S. Department of Agriculture, U.S. Forest Service, Deschutes National Forest, and the U.S. Department of Interior, Bureau of Land Management (BLM) proposed Plans of Operations for Geothermal Exploration, Development, Production, Utilization, and Disposal. The plans were submitted as part of the U.S. Department of Energy, Bonneville Power Administration (BPA) Geothermal Pilot Program. Under these plans, CEE proposes to build and operate a 33-megawatt (MW) electric geothermal power plant and supporting facilities on Federal geothermal leases. These leases are located on the west flank of Newberry Volcano within the Deschutes National Forest, Deschutes County, Oregon (Figure 1.1-1). The power plant would be capable of generating 33 MW (gross output) of electric power. CEE is a Portland, Oregon-based, subsidiary of California Energy Company, Inc., of Omaha, Nebraska. California Energy Company, Inc., owns and operates six geothermal power facilities, generating over 300 MW of power at sites located in Nevada, Utah, and California.

CEE entered into a joint development agreement with the Eugene Water & Electric Board (EWEB) for the development and marketing of geothermal electrical power from the CEE leases. Under this agreement, EWEB would purchase 10 MW of power produced from the project. BPA would purchase 20 MW under a power purchase agreement. About 3 MW would be consumed in operation of the plant and on the transmission line.

This Environmental Impact Statement (EIS) addresses the potential environmental effects of the proposed action and alternatives.

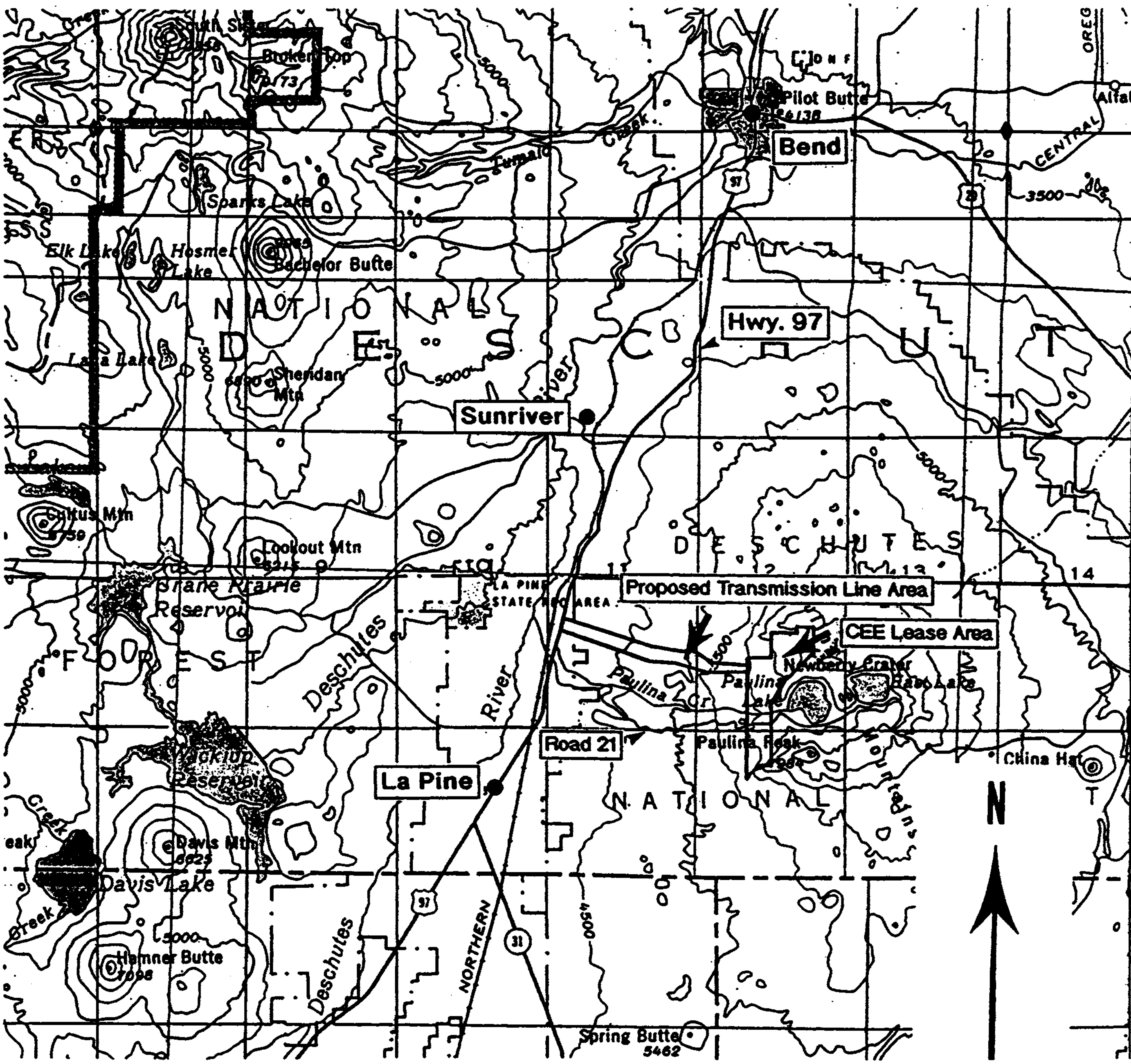
1.2. PURPOSE AND NEED

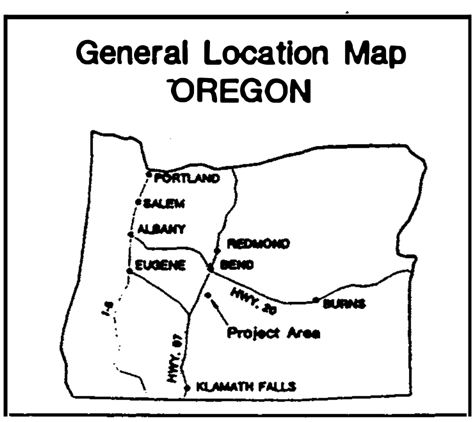
The intent of the Newberry Geothermal Pilot Project is to demonstrate whether geothermal energy at Newberry Volcano can provide a reliable, economical, environmentally acceptable, and technically feasible alternative source of electricity for the public. The need for Federal action is to decide whether to enable the development of the CEE/EWEB proposal for a geothermal power project at Newberry Volcano. The U.S. Forest Service, BLM, and BPA have determined this to be a major Federal action requiring an EIS under the National Environmental Policy Act (NEPA) and its implementing regulations (40 CFR 1500-1508). The agencies will determine whether the project, or alternatives to the project, should be permitted to proceed. The agencies may choose the no-action alternative, thereby denying the proposed geothermal development activity. Agency decisions will be documented in Records of Decision (ROD) for the EIS. If an action alternative is chosen, additional mitigation measures, conditions, and stipulations may be included as part of the decision. Any subsequent actions taken by the agencies to implement the decision must be consistent with the RODs.

To ensure timely and efficient application of the NEPA process, and participation by appropriate Federal agencies, lead and cooperating agencies were designated, and each has its own specific purposes for involvement. Because the proposed project would occur on National Forest lands subject to the legislation that established the Newberry National Volcanic Monument (NNVM) (Public Law 101-522, November 5, 1990), the U.S. Forest Service, BLM, and BPA agree that the U.S. Forest Service is the lead agency for the analysis and preparation of the EIS, and that BLM and BPA are cooperating agencies for this project.

As the lead agency, as well as the agency responsible for surface management, the U.S. Forest Service's purpose is to decide whether to approve the proposed geothermal development activity and take action on the following approvals and authorizations:

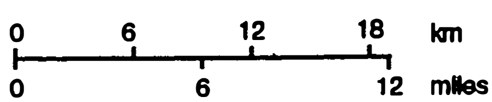
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Vicinity Map and Proposed Project Area	Figure 1.1-1





__Note:__ The boundaries of the Lease Area and Transmission Line Area are approximate in nature.

Scale



- Approval of Plans of Operations for Exploration, Development, Production, Utilization, and Disposal elements of the project
- Authorization for, and approval of, specifications for surface disturbance and occupancy
- Approval of a Plan of Utilization and Disposal for the proposed project, including construction of a 33-megawatt (gross output) geothermal power plant and associated pipelines and transmission lines

This EIS is tiered[1] to the Deschutes Forest Plan EIS, which was consulted, and it was determined that the project is consistent with the Deschutes National Forest Land and Resource Management Plan (U.S. Department of Agriculture 1990a).[2]

BLM is the Federal agency responsible for management and administration of Federal mineral leases and subsurface activities, including geothermal drilling, pursuant to the Geothermal Steam Act of 1970 and related regulations. BLM's purpose is to decide whether to approve the proposed geothermal development activity and take action on the following permits and approvals for surface and subsurface activities:

- Approval of Plans of Operations, Exploration, Development, Production, Utilization, and Disposal phases of the proposed project
- Issuance of individual Geothermal Drilling Permits
- Approval of Plans of Utilization and Disposal for the proposed project, including construction of a 33-megawatt (gross output) geothermal power plant and associated pipelines and transmission lines
- Issuance of a two-part Geothermal Utilization Permit
- Approval of a Site License
- Approval of Lease Unitization Agreement

BPA is one of the U.S. Department of Energy's five power marketing agencies. Congress created BPA in 1937 to market and transmit the power produced at Bonneville Dam. Today, BPA markets the power from 30 Federal dams and one non-federal nuclear plant in the Pacific Northwest, and has one of the largest transmission systems in the United States. BPA sells wholesale power to public and private utilities, as well as to some large industries. BPA also exchanges power with utilities in California and Canada. BPA's purposes are to:

- Assure consistency with BPA's statutory responsibilities, including the Pacific Northwest Power Planning and Conservation Act (Northwest Power Act) (U.S. Congress 1980), while taking into consideration the Pacific Northwest Power Planning Council's (NWPPC) Conservation and Electric Power Plan and Fish and Wildlife Program
- Restore and enhance environmental quality and avoid or minimize potential adverse environmental effects in its power transmission projects

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[1]Tiering is a way to incorporate by reference a discussion of issues that have been covered in a previous EIS. It allows an agency "to focus on issues which are ripe for decision and exclude from consideration issues already decided or not ripe" (Council on Environmental Quality 1992).

[2]This is also referred to in the EIS as the Forest Plan or the Land Management Plan.

- Test the availability of geothermal energy to provide a reliable, economical, and environmentally acceptable alternative energy source that will help meet the region's power needs

Ultimately, BPA will decide whether to take the following actions:

- Execution of a contract to transmit power from the Project to EWEB
- Execution of a power purchase agreement with CEE
- Execution of a billing credit agreement with EWEB

1.3. BACKGROUND INFORMATION

1.3.1. Project Overview

CEE has submitted to the U.S. Forest Service and BLM a proposal to build and operate a 33-MW geothermal power plant and supporting facilities on the west flank of Newberry Volcano. These facilities would be located on Federal lands outside the NNVM.

The project would be undertaken as part of BPA's Geothermal Pilot Program. The goal of this program is to initiate development of the Pacific Northwest's large, but essentially untapped, geothermal resources, and to make sure they will be available to meet the energy needs of this region. The primary underlying objective of this project is to provide an alternative source of electrical power to help meet growing regional power demands and needs. More information on BPA's Geothermal Pilot Program can be found in (Darr 1990) and (Northwest Power Planning Council 1991).

Drilling up to 4 wells at each of 14 well pad locations, for a total of 56 wells, has been proposed. The project involves drilling and testing an adequate number of production and injection wells to supply the 33MW power plant, as well as drilling exploration wells to define an area with a 100-MW reserve of geothermal resources. Four small-diameter wells (temperature gradient/core holes) would be drilled at four of the 14 pad locations. If the small diameter wells are successful, deeper exploration or production wells could be drilled from the same location. The 100-MW reserve will assure future availability and could be used for future power generation. However, there is no certainty that these reserves will be found, and no power plants beyond the first 33-MW unit have been proposed. Additional units would require further environmental analysis and are beyond the scope of this EIS.

Wells to supply the plant would be drilled from 11 well pads located north of Paulina Creek. The power plant is expected to initially require 8 to 10 production wells and 3 to 5 injection wells. Additional replacement wells may be required over the life of the project. Above-ground pipelines would connect the production and injection wells to the power plant. About 3.2 km (2 miles) of new access roads would be built.

The three well pads south of Paulina Creek are for exploration purposes only and would be used to help confirm the extent of the geothermal resource. The three well pads and the up to 12 wells that could be drilled south of Paulina Creek would not be connected (either by roads or pipelines) to the proposed power plant north of Paulina Creek. Additional environmental analyses would be required before additional development (beyond the 33 MW) could occur north or south of Paulina Creek.

About 13.1 km (8.2 miles) of overhead transmission line would connect the power plant to a Midstate Electric Cooperative line west of Highway 97. The power would be sold to BPA and EWEB under long-term (50-year) contracts. If a project is approved, exploration drilling could begin as early as fall 1994, and the power plant could start operating in late 1996 or early 1997.

Before making any major decisions regarding this project, the U.S. Forest Service, BLM, and BPA must determine what effects the project may have on the environment. This EIS addresses the potential environmental effects of the proposed action and alternatives.

Various types of environmental data were collected before and during the preparation of this EIS. One purpose of the "baseline" data is to document existing conditions for the project area prior to construction and operation for comparison with future conditions. If a project is approved, BLM will require the developers to implement a data collection and monitoring program to help ensure protection of the environment.

1.3.2. What is Geothermal Energy?

1.3.2.1. How Would the Project Work?

Geothermal energy is heat energy from deep in the earth. This heat is brought near the surface by deep circulation of groundwater or by intrusion of molten magma. Geothermal systems are a combination of three components — near-surface heat, permeable rock, and water. There are several kinds of geothermal resources, differing in the extent to which they have each component. The Newberry Geothermal Project hopes to tap a "hydrothermal" system, which has all three components. An example of a hypothetical hydrothermal system is shown in Figures 1.3-1 and 1.3-2.

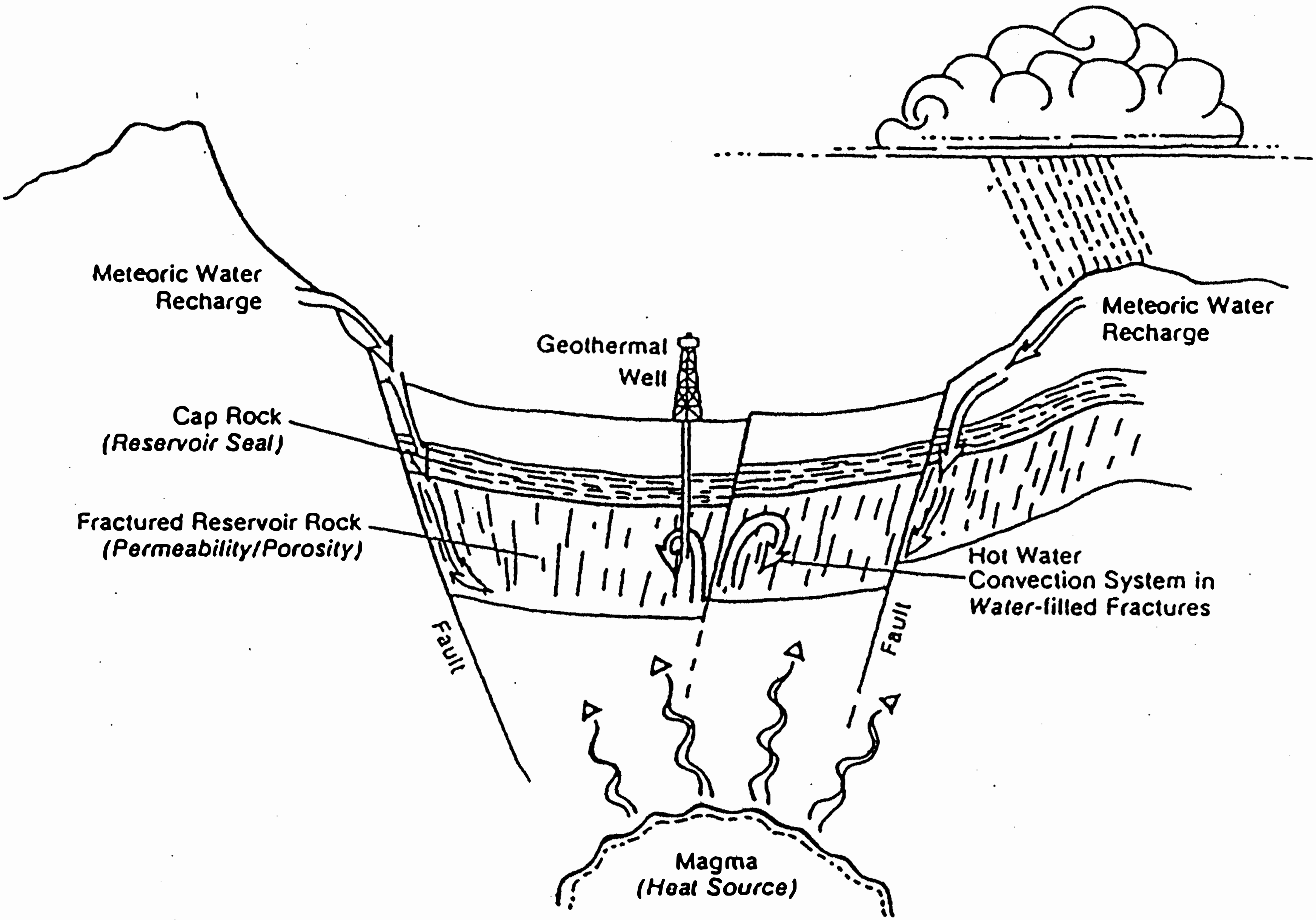
Water is heated through natural processes by circulating along faults in the earth's crust or through zones of fractured rock. Scientists have developed a mental picture of the hydrothermal system in the Newberry Caldera based on the existing information and by analogy to other geothermal systems. It has hot water and steam moving along fractures from the heated rocks above the magma chamber. A small portion of the steam follows fractures upward through a cap consisting of highly altered volcanic rocks and dense lava flows. Above this cap within the caldera, this steam mixes with local ground water to form a shallow hydrothermal system. The shallow system includes the warm water in the hot springs. Most of the steam does not rise through cap but remains as part of the deep hydrothermal system. This deeper system is proposed for development at Newberry.

Hot water and steam are discovered through geothermal exploration programs and are brought to the surface by drilling wells. At Newberry, these wells would be relatively deep (1,830 to 2,743 meters [6,000 to 9,000 feet] or more below the surface). Many of the wells would be drilled at an angle (directionally drilled) to get closer to the heat source under the caldera and to increase the chances of intersecting fractures. Drilling is proposed to be done on well pads located on the portion of the CEE leases which allow surface occupancy, and outside the NNVM and the Special Management Area (SMA) (Figure 1.3-3). Some well bores may extend under the SMA, but not under the Monument.

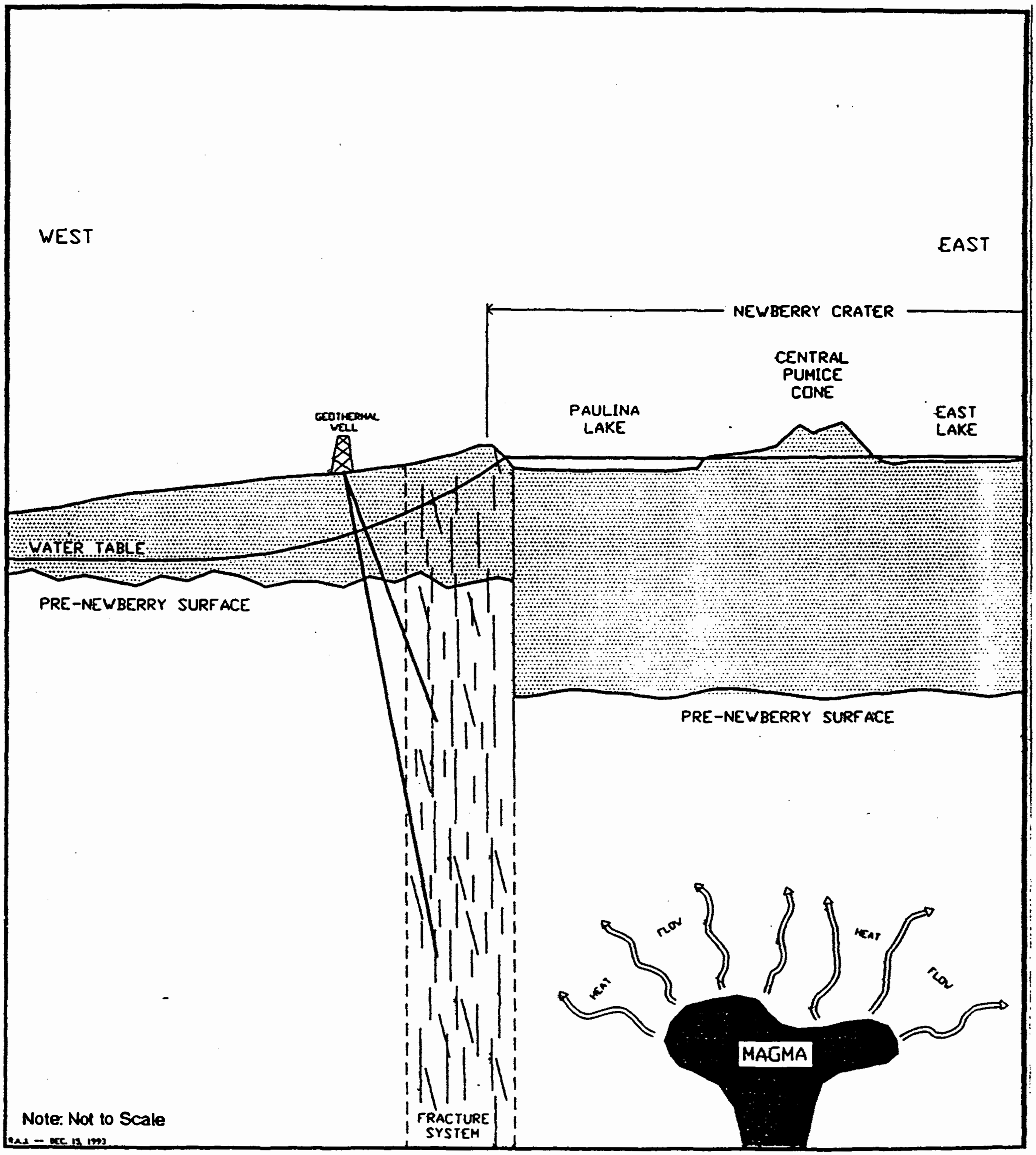
To prevent contact between thermal fluids and groundwater, wellbores are lined with steel pipe set in concrete to below the groundwater zone. The number of wells required depends on the temperature and quantity of fluid encountered by each well. Some of the wells would only be used to measure the change in temperature with depth (temperature gradient holes) or to obtain a continuous rock sample for study (core holes). From eight to ten production wells and three to five injection wells would initially be needed for the operation of the power plant.

Scientific drilling in the Newberry Caldera by the U.S. Geological Survey encountered 265°Celsius (C) (509°Fahrenheit [F]) fluid, so the type of power plant technology proposed by CEE is based on the expectation of finding fluids at approximately this temperature. It is also expected that the geothermal fluids in this resource will be a two-phase steam-water mixture, not just steam. Experience elsewhere has shown that a "double-flash" type power plant would be the most efficient and economical for this type of resource. Double-flash plants are based on proven technology, and many of them operate reliably in the United States and elsewhere.

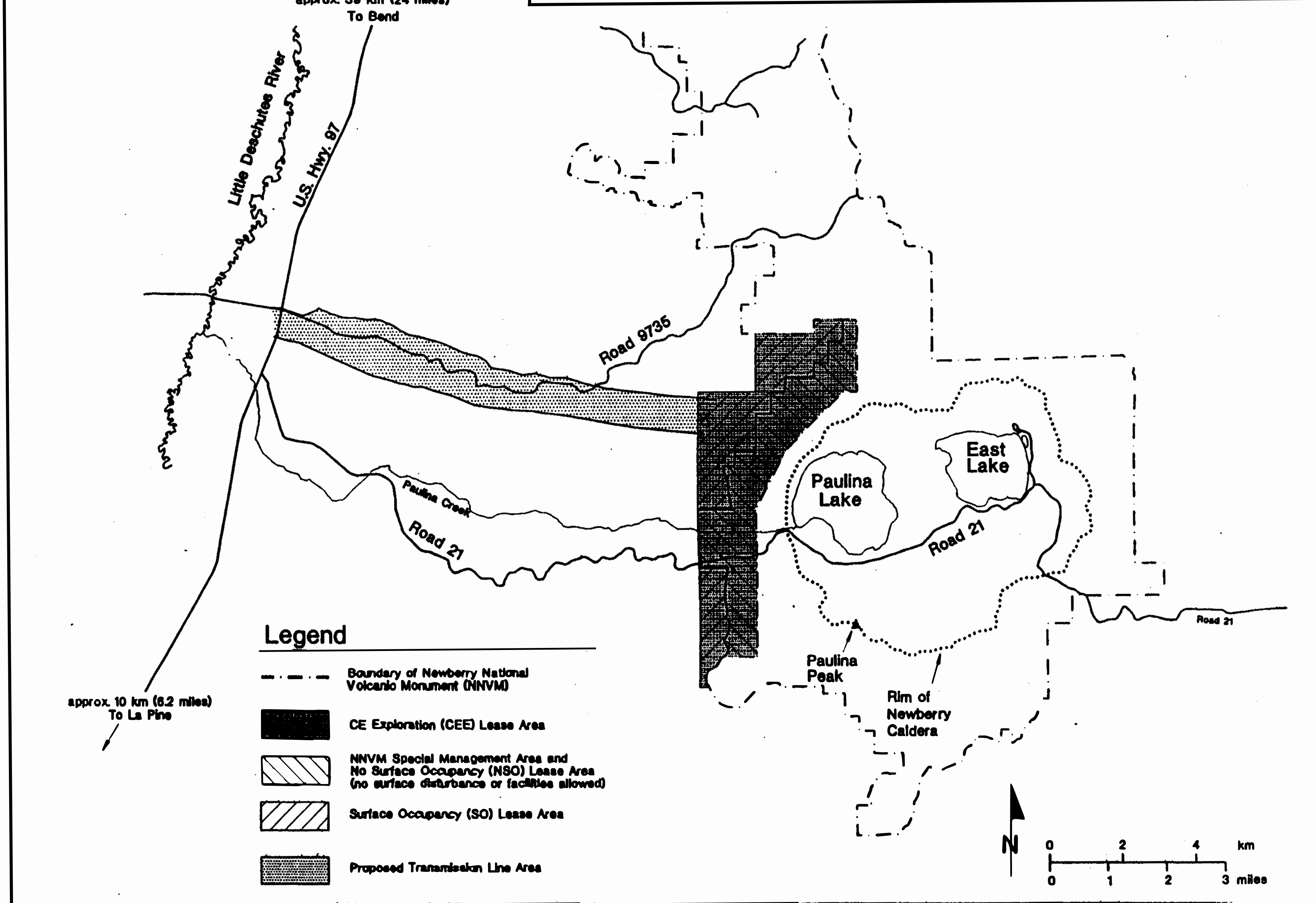
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Conceptual Depiction of a Hypothetical Hydrothermal System	Figure 1.3-1



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Newberry Volcano: Conceptual Depiction of Hydrothermal System	Figure 1.3-2



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Proposed Project Area and Nearby Vicinity	Figure 1.3-3



1.3.2.2. How a Double-Flash Plant Works

In a typical double-flash power plant, hot water and steam flow under pressure up and out of the production wells. At or near the wellhead, the pressure is allowed to drop in a wellhead "separator," and more of the water "flashes" to steam. The steam and remaining hot water flow in separate pipes to the power plant. At the power plant, the steam drives the high-pressure stage of a turbine. The hot water from the well is combined with hot water from the other wells in a low-pressure separator, where more of the water flashes to steam. This steam drives the low-pressure stage of the turbine. The turbine is connected to an electric generator. The power conversion process is illustrated in Figures 2.4-20 and 4.5-2.

After passing through the turbine, the spent steam goes to a condenser, where it is converted back to water, passed through a cooling tower (to cool the water to use in the condenser), and piped to injection wells to replenish the geothermal reservoir. Some of the cooling water turns to steam or "drift" in the cooling tower and is discharged to the atmosphere, where it may sometimes be visible as a steam plume. Certain gases, such as hydrogen sulfide (the rotten egg smell associated with hot springs), do not condense to liquid with the water and must be removed chemically and disposed.

The proposed power plant would be able to produce about 33 MW, but about 3 MW of this would be used by the plant itself to run pumps and other equipment. The 30 MW of net generation would meet the needs of about 15,000 households. The electricity would be transmitted over a 115-kilovolt (kV) transmission line to a point west of Highway 97, where it would connect with an existing Midstate Electric Cooperative line. The proposed ransmission line is sized to allow future expansion without rebuilding the line, and would be sized to have an ultimate capacity of about 100 MW. Midstate's line connects to the BPA transmission grid at LaPine.

1.3.2.3. Project Stages

The project would have four stages — exploration, development, utilization, and decommissioning. Exploration consists of drilling wells to gain further knowledge of subsurface geology and to determine the existence and commercial potential of the geothermal resource. If a viable hydrothermal reservoir is not discovered, the project would be reassessed and would most likely result in the plugging and abandonment of non-productive wells. The wells would be plugged with concrete and the well pads returned to their natural state.

If exploration is successful, the development stage of the project would begin. Additional wells would be drilled to supply fluid to the power plant and to inject spent fluid. Development would also include the construction of production well pads and access roads, pipelines, the power plant, and transmission line. Utilization (also called operation) would include power plant, pipeline, and transmission line testing and operation. Decommissioning would consist of activities, such as plugging wells and restoring the plant site, that take place when the project ceases operations. The proposed project is expected to operate for at least 50 years.

1.3.2.4. Power Contracts

BPA will not make a decision whether to sign the power purchase and other agreements until after the EIS is completed and a Record of Decision is made, so these agreements are considered to be still under negotiation and are not available to the public at this time. However, some contract principles may influence the environmental impacts of the project and should therefore be mentioned in the EIS.

CEE, EWEB, and BPA have agreed that EWEB would buy 10 MW of output from the project and BPA would take the remaining 20 MW. The contract term is 50 years. EWEB and BPA have an option on up to 33 and 67 MW, respectively, of additional geothermal power developed on CEE's leases, if this power is available. Additional environmental analysis would be required before any additional generation facilities could be approved.

All parties want to ensure that the Newberry resource is used in a way that can be sustained over a very long term, if not indefinitely. The degree of "sustainability" would not be known until the reservoir had been tested for a period of time (by operating the power plant) and the amount of natural recharge can be estimated. Evidence suggests that resource depletion that has occurred at other geothermal power development sites — with The Geysers in northern California being the biggest and best-known example — was due to one or more of these factors:

- Little or no natural recharge to the reservoir.
- Little or no injection of spent geothermal fluid to recharge the reservoir.
- Too rapid development — new plants were built before reservoir response to previous plants was known.
- Uncontrolled development — multiple developers competed for the same resource.
- The steam fields and power plants had different owners, with payment to the steam field owner based on the amount of electricity produced. This arrangement resulted in inefficient power plants that wasted the resource.

The power contracts for the Newberry Geothermal Project attempt to address these problems by including the following provisions:

- The entire lease block must continue to be controlled by CEE.
- Both the steam field facilities and power plant will be owned by CEE.
- CEE cannot build a second plant until they have demonstrated that the reservoir can fuel the first plant for at least 50 years. (A second plant would require additional environmental review.)
- Large financial penalties and/or contract termination would result if output declines due to CEE-caused reservoir depletion.
- Contract termination accompanied by large financial penalties would result if CEE fails to comply with environmental regulations.

CEE has agreed to these provisions, some of which may be unique in the history of geothermal development. It should also be noted that BPA conducts periodic environmental audits of its projects to ensure compliance with mitigation measures imposed as a result of the NEPA review. On-going monitoring by the BLM and U.S. Forest Service will also ensure compliance.

1.3.3. Why Geothermal Energy?

Geothermal resources are thought to be abundant in some areas of the Pacific Northwest, with a high potential for also being environmentally sound and cost-effective. Although experience elsewhere in the United States and in other countries has shown geothermal can be a reliable renewable energy source, it has yet to be developed in the Northwest for the commercial production of electricity. Geothermal is promising as an alternative to fossil fuel, nuclear, and hydroelectric energy, which have been the traditional sources of power for the region.

BPA has determined that geothermal power is a renewable, alternative source of electrical power that could help meet future energy needs in the Pacific Northwest (Bloomquist and others 1985). BPA's Resource Programs Environmental Impact Statement (RPEIS) considered the environmental trade-offs among the various types of energy resources available and the environmental impacts of adding these resources to its existing power system (Bonneville Power Administration 1993d). Resources examined included conservation, hydropower, geothermal, wind, solar, cogeneration, combustion turbines, coal, and nuclear. The analysis in the RPEIS showed that geothermal is a reliable source of electrical power that can help meet energy needs in the Pacific Northwest. The alternative BPA decided to pursue included the acquisition of all cost-effective conservation and efficiency improvements, supplemented by a mix of renewables (including geothermal energy) and thermal resources. The acquisition of a geothermal resource is consistent with this decision.

The NWPPC forecasts potential regional electricity shortages in the next few years unless new energy sources are developed (Northwest Power Planning Council 1991). These shortages will be caused by several factors, including population growth, changes in the operations of BPA's hydroelectric system to increase fish survival, shutdown of the Trojan nuclear plant, and other factors. Failure to plan for the acquisition of additional resources could result in power shortages and occasional brownouts or blackouts for some communities and industrial customers.

The Northwest Power Act prioritized new resources for energy production to be acquired by BPA, with renewable energy sources such as geothermal and solar having second priority after conservation. The Northwest Power Act also authorized BPA to acquire experimental, demonstration, or pilot projects having potential for providing cost-effective service to its customers.

Geothermal plants, especially those installed in the last decade, have shown themselves to be one of the most reliable energy sources available. Capacity factor — the amount of energy a unit actually generates during a year compared to its maximum rated output — is a measure of plant performance. Newer geothermal plants typically have capacity factors in the high 90-percent range (Oregon Department of Energy 1994). This compares to 46 percent for hydroelectric, 20 percent for wind, 68 percent for new coal-fired units, and 66 percent for nuclear. The average annual capacity factor for all U.S. geothermal plants (both old and new) is 73 percent (U.S. Department of Energy 1991b).

1.3.4. Why Newberry Volcano?

The geothermal potential at Newberry Volcano has been recognized by past actions, including:

- A Known Geothermal Resource Area was designated by the U.S. Geological Survey. Federal geothermal leases have been offered and issued in the area (U.S. Department of Interior 1976).
- In its 1986 Power Plan, the NWPPC judged Newberry Volcano to be among the sites with the highest potential for cost-effective development (Northwest Power Planning Council 1986).
- Management and development of geothermal energy sources are addressed and allowed for in the U.S. Forest Service's land management programs. The proposed project location is within an area recognized as a potential geothermal development area by the 1990 Deschutes National Forest Plan (U.S. Department of Agriculture 1990a and 1990b).
- The potential for geothermal development was addressed and provided for in the 1990 legislation that created the Newberry National Volcanic Monument (U.S. Congress 1990).

1.3.5. Who are the Proponents?

Consistent with recommendations by the NWPPC, BPA in its 1990 Resource Program agreed to participate in up to three geothermal pilot projects with the aims of confirming the existence of high-potential geothermal reservoirs, and of demonstrating that they can be developed for electric power production. These projects would be joint ventures with regional utilities. In July 1991, BPA published a Request for Proposals to solicit proposals by developers and utility partners interested in exploring and developing geothermal resources in the Northwest.

In December 1991, BPA selected a proposal submitted by CEE (an independent company specializing in production of geothermal power) and EWEB (a publicly-owned utility serving the Eugene/Springfield area in Oregon) for a project at Newberry Volcano, as one of three pilot projects. In December 1992, BPA signed a Memorandum of Understanding with CEE and EWEB, signifying agreement on contract principles (see Appendix I). CEE and EWEB are the proponents for this project, and CEE holds Federal geothermal leases in the area they propose to develop.

1.4. ENVIRONMENTAL LEGISLATION GOVERNING THE PROJECT

The EIS is being prepared in consultation with other Federal, state, and local government agencies and in the context of a number of other Federal, state, and local environmental laws and executive orders. Some of the key laws that pertain to the proposed project that must be followed if the project is implemented include:

- American Indian Religious Freedom Act
- Archaeological Resources Protection Act
- Clean Air Act
- Clean Water Act
- Endangered Species Act
- Hazardous Materials Transportation Act
- Solid Waste Disposal Act
- National Environmental Policy Act
- National Forest Management Act
- National Historic Preservation Act
- Native American Graves Protection and Repatriation Act
- Newberry National Volcanic Monument Act
- Occupational Safety and Health Act (OSHA)
- Oregon Hazardous Waste Rules
- Oregon Revised Statutes (Department of Environmental Quality, Water Resources Department, and Department of Geology and Mineral Industries revisions to, or adoptions of, the Federal laws for the environment)
- Public Utilities Regulatory Policies Act
- Geothermal Steam Act of 1970

1.4.1. National Environmental Policy Act (NEPA)

The legislation that governs the preparation of this EIS is NEPA, enacted in 1970 to provide information to the public about potential impacts of Federal actions. Unlike other single-topic environmental laws, NEPA encourages the protection of all aspects of the environment. NEPA applies to most projects which in some way involve discretionary actions by Federal government agencies, if they are deemed likely to cause environmental impacts. The purpose of NEPA is to help Federal decision-makers take actions that protect, restore, and enhance the quality of the human environment based on an understanding of environmental consequences. The EIS provides the information needed for these decisions.

The EIS describes important environmental and social/economic impacts which may result from the proposed project and alternatives to the project. The EIS focuses on cause-and-effect relationships and provides sufficient information and analyses to identify the magnitude of those impacts, including ways to avoid or minimize harm to the environment. The EIS also evaluates alternatives to the proposed project, including the no-action alternative.

1.5. PERMITTING PROCESS AND APPROVALS NEEDED

1.5.1. The Environmental Analysis Process

Once it was determined that this project would involve a major Federal action which may significantly affect the quality of the human environment, the lead agency, U.S. Forest Service, announced its intent to prepare an EIS by publishing a Notice of Intent (NOI) in the Federal Register on December 2, 1992. The NOI announced the times and places scheduled for public and agency "scoping" meetings. The purpose of the meetings was to ask government agencies, citizen groups, and the public to provide input about issues that should be addressed during the environmental review process.

According to NEPA regulations, the scoping process is used to identify significant environmental issues deserving study in the EIS process. The issues raised during scoping for the Newberry Geothermal Pilot Project EIS are identified in the analysis of the effects of the proposed action and alternatives. They are summarized in Section 1.6.

An Initial Study Plan was prepared prior to scoping to determine preliminary issues to be addressed in the EIS. After scoping (described in Appendix A), the Initial Study Plan was updated, alternatives to the proposed action were developed, and the effects of these alternatives were analyzed. Existing data were used, and additional necessary environmental analyses and surveys were conducted. Analyses included review of existing data and literature, as well as new field investigations. The Draft EIS (DEIS) was distributed for a 73-day period of public and agency comment. Three public meetings and one agency meeting were held during the comment period.

Written comments and questions about the DEIS were compiled for response in the Final EIS (FEIS). The FEIS responds to comments and questions received. The FEIS will be fully considered by Federal decision-makers before any of the alternatives, including the proposed action, are approved or undertaken. The decision on whether the project should proceed and whether the required permits and approvals should be granted will be based upon the review of the FEIS and will be contained within the written RODs issued by the U.S. Forest Service, BPA, and BLM.

The EIS is organized to meet all requirements of NEPA and to provide a readable document to the public and agencies who will review the proposed project. The major sections of the EIS include:

- Project overview, purpose and need for the proposed action

- Description of the alternatives, including the proposed action and the no-action alternative
- Comparison of action alternatives and effects
- Description of the environment that could be affected by the proposed action or alternatives
- Environmental consequences of the proposed action and alternatives

A planning record has been compiled throughout the EIS process. The planning record contains the analysis and documentation for the EIS, including communication records, technical data, references, and NEPA work products.

The cost of the EIS is expected to total approximately $1,000,000. This includes costs of conducting the public process, writing and distributing the draft and final EIS, and performing the studies needed for the document. Almost all of this cost will be borne by CEE.

1.5.2. Implementation Process

If the proposed project or an alternative is approved, additional actions would have to be taken after this EIS process is completed and prior to CEE initiating surface disturbance for any aspect of the project. Authorization for implementation and surface disturbance would require specific approvals from the U.S. Forest Service and BLM before on-the-ground operations commence and throughout the implementation process. The implementation approval process would be based on terms described in an Interagency Agreement between the U.S. Forest Service and BLM.

1.5.3. Other Permits Needed by CEE

In addition to the authorizations listed in Section 1.2 (Purpose and Need) for the proposed project, CEE would also be responsible for acquiring permits from various Oregon agencies. For example, the Oregon Department of Geology and Mineral Industries has regulatory authority for well drilling and certain other activities proposed for this project, and would require a geothermal drilling permit under ORS Chapter 632, Division 20. Some of the major permits and agencies that issue them are listed below in Table 1.5-1.

1.6. THE SCOPING PROCESS AND THE ISSUES RAISED

One of the early steps in the preparation of this EIS was to contact citizens, government agencies, and public interest groups to help identify issues and concerns. Additionally, issues were raised by agency personnel and technical specialists involved with the preparation of this analysis. This process is referred to as "scoping," because it is designed to help establish and define the scope of analysis for the EIS. Scoping also helps to ensure that all relevant environmental issues are addressed in the EIS. Appendix A provides more information on scoping.

1.6.1. What Issues Were Raised?

The issues raised during scoping related to the EIS process, the proposed project and alternatives, and to the environmental aspects addressed in this EIS (e.g., air quality, recreation, etc.). A summary of the issues raised during scoping is presented below, organized by various subjects.

Table 1.5-1 Project Permits Required from Oregon Agencies*

Permit	Agency	Timing
Energy Facility Siting Certificate	Energy Facility Siting Council	Pre-construction
Geothermal Drilling Permit	Department of Geology and Mineral Industries	Pre-construction
Air Contaminant Discharge Permit	Department of Environmental Quality (DEQ)	Pre-construction
Stormwater Discharge Permit	Department of Environmental Quality	Pre-construction
Hazardous Waste Identification Number	Department of Environmental Quality	Pre-operation
Water Pollution Control Facility Permit	DEQ, Water Resources Department	Pre-construction
Water Rights Permit	DEQ, Water Resources Department	Pre-construction
Qualifying Facility Certification	Oregon Public Utility Commission	Pre-construction
Overhead Line Crossing Permit	Oregon Department of Transportation	Pre-construction
Overweight Hauling Permit	Oregon Department of Transportation	Pre-construction

* It is CEE's responsibility to obtain and comply with these permits. Some of the permits listed may not be necessary, depending upon final project design.

1.6.1.1. EIS Process

Issues and questions raised in relation to the scoping part of the EIS process included: whether only issues raised by the public during scoping would be addressed; the observation that scoping meetings seemed to emphasize metropolitan areas; and whether the Central Oregon Geothermal Working Group[1] (COGWG) concerns would be included. There was a desire to be kept informed about environmental impacts. Other issues were related to what the EIS would cover: Would it address larger or more plants; would exploration and operation be addressed; would monitoring programs and funding be included; would limits of acceptable change be identified and criteria set; and would the EIS set threshold limits that would prevent other geothermal developers from developing their leases. Whether or not other permits and approvals would be required was raised as an issue. Concerns that the EIS timeline should be short to reduce cost and that a disclosure be prepared of the cost to taxpayers were also raised.

1.6.1.2. Proposed Project and Alternatives

Numerous questions and comments were received about elements of the proposed project, including operations, reclamation, location, potential alternatives, and potential mitigation. Comments about the proposed project included requests for detailed information about its specific location, physical and operational elements; concerns over how much land would be disturbed; suggestions to proceed cautiously with development; questions about how pollution would be avoided; concerns whether expansion was possible and covered in the EIS; interest in how long the

[1]The Central Oregon Geothermal Working Group consists of citizens from the Bend-Sunriver-LaPine area and the Confederated Tribes of Warm Springs. The group met monthly over a two-year period beginning in early 1992 for the purposes of learning about the proposed project and advising the project sponsors regarding issues of concern to the community.

resource would last; expressions of support for geothermal energy; concerns whether the trade-offs would be worthwhile; questions about reclamation, regulatory review, and permits/approvals; and what the Newberry National Volcanic Monument legislation guaranteed geothermal developers. Comments related to alternatives included requests for (1) consideration of wind and solar power, (2) locations outside CEE leases, (3) smaller generating capacity, (4) burying the transmission lines, (5) minimizing right of way width for transmission lines, (6) alternative power line routes, (7) conducting a comparative analysis of other alternative energy developments, and (8) raising rates to reduce demand.

1.6.1.3. Geology and Soils

Questions and comments about geology and soils included requests for detailed information about baseline conditions, the extent of project impacts on soils, proposed reclamation methods, potential for earthquake damage, and a request from the Oregon State Department of Geology and Mineral Industries — one agency responsible for working cooperatively with BLM for well permitting — to be kept informed about the project.

1.6.1.4. Water Quality/Resources

A variety of comments on water quality and hydrology were received. Questions were raised about whether permits for water use would be needed, whether water would be made available to wildlife, how much water would be used by the various phases of the project, and what quality of water would be used by various phases of the project. Other questions related to whether there was a subsurface connection between the geothermal reservoir the project proposed to tap and the hot springs in the caldera; the potential for contamination of groundwater aquifers and water supplies; potential for well blowouts and their impact on groundwater; impacts on groundwater availability; and effects on water quality of the lakes within the caldera, Paulina Creek, and other surface waters.

1.6.1.5. Geothermal Resources

Issues raised relating to geothermal resources included questions about the longevity of the resource and concerns that the resource not be depleted by development; uncertainty about the predictability of impacts of development, including potential effects on the hot springs and other geothermal features in the caldera, groundwater quality, and depletion of the aquifer. There were questions about whether there would be a monitoring program and what it would include, what the chemical quality of the geothermal fluid would be, whether there were any potential problems that could not be mitigated, and whether monitoring wells would be drilled. One commentator stated that standards should be established and that if they were not met, the development should be canceled.

Other commentators (1) asked if steam could be injected to eliminate the need for cooling towers, (2) suggested that supplemental water injection be considered, and (3) asked whether additional wells would be drilled if production dropped in older wells.

1.6.1.6. Air Quality

Comments and questions broadly encompassed potential emissions and air quality impacts from construction through operation. Commentors requested detailed data on (1) existing air quality and meteorology, (2) pollution and emissions (including odors, steam, and toxics) generated by the proposed project during operation (3) emissions generated during construction, exploratory drilling, and well testing, (4) an assessment of air quality impacts of the project, (5) whether cumulative impacts would be addressed, and (6) effects of pollutants on vegetation, wildlife, and tourism. One commentor stated that claims that carbon dioxide (CO_2) emissions from combustion-based power sources were harmful to the environment were unsupported.

1.6.1.7. Visual Resources

Requests for detailed information about the visibility of the project facilities from sensitive locations in the region formed the basis for most of the comments received on this subject. The effect of visual change on users, including tourists, was a concern. Information on what types of visual mitigation would be proposed was also requested.

1.6.1.8. Noise

Issues related to noise impacts included concerns about noise levels and durations predicted to result from the various aspects of the project. It was also questioned whether noise would be audible at sensitive sites such as within the caldera, effects of noise on wildlife, and whether mitigation would be employed.

1.6.1.9. Land Use

Comments specific to land use included concerns about intrusion of an industrial use onto historically nonindustrial lands, effects of construction on land use, impacts to the roadless area, a need to coordinate with the planning process for the NNVM and Monument Advisory Council, and impacts on the eligibility of Paulina Creek for Wild and Scenic Status.

1.6.1.10. Recreational Resources

Other comments were related to recreation and tourism uses, and included concerns about having an accurate baseline description of existing recreational use. There were questions about the economic effects of the project on recreational use and tourism, concerns about how existing uses such as Nordic skiing and snowmobiling could coexist with the proposed project, whether some benefit to recreation could result from mitigation for the proposed development, effects on hunting opportunities, and impacts on recreational and scientific use of the hot springs and lakes in the caldera and Paulina Creek.

1.6.1.11. Transportation/Traffic

The issues raised included concerns about access restrictions, creation of additional access for recreation, traffic impacts, hazards from waste transportation, compensation for impacts on existing roads from project related traffic, impacts on current public and U.S. Forest Service road needs, requests for information on traffic during all phases of the project, and a question about what materials would be used in new roads.

1.6.1.12. Biological Resources

Comments on vegetation included questions about impacts of air pollution on plants, impacts on vegetation in the roadless area, requests that detailed baseline information be available, concerns about impacts on old growth forest, and questions about seed mixes for reclamation.

Wildlife related comments and questions included requests for detailed baseline information on existing wildlife species composition and movement patterns; project impacts on wildlife migration and movement routes; concerns about habitat fragmentation, increased road kills and poaching, magnetic fields, noise, water quality, air pollutants, use of the roadless area, avoidance of the area, and night lighting. Other concerns included questions about how impacts would be identified, tracked, and mitigated. There were questions about seasonal limits to development. Fish and aquatic resources concerns included questions about water quality impacts on Paulina Creek and Paulina and East Lakes; changes to surface water distribution; and a request for full mitigation of adverse impacts. Concerns about impacts on threatened, endangered, and special-status species were voiced.

General comments expressed concerns about significant ecosystem values, special wildlife management areas, monitoring needs and funding, adequacy of baseline data and time available to gather it, and cumulative impacts.

1.6.1.13. Archaeological, Historic, and Cultural Resources

Comments and questions focused on potential impacts to archaeological sites and potential impacts to Native American traditional cultural properties. They included concerns about existing data on cultural resource sites; potential impacts; facilitation of Section 106 compliance by Tribes; disruption of traditional cultural properties; whether all appropriate Tribes were included in the consultation process; whether cumulative impacts would be addressed; and a comment that the project area is within land ceded to the U.S. by the Klamath Tribe.

1.6.1.14. Human Health and Safety

Issues raised during scoping included concerns about pollution from drilling, materials used at the plant, pollution generated from the geothermal fluid, and effects on groundwater and drinking water supply. Concerns were raised about hazards from fire, transportation and accidental spills of toxics, whether hunting in the area would pose a risk to workers and equipment, and whether landowners would be compensated if their groundwater supplies were contaminated.

1.6.1.15. Socioeconomics

The chief concerns were related to whether the proposed project would benefit the project area directly, or if it would merely generate power to serve distant areas with no benefits to the local area. Other concerns included whether there was a secondary user for the hot water, whether the materials used would be most economical for construction, whether jobs would go to local workers; effects on tourism, particularly visual impacts and potential for hazardous material spills; and loss of subsistence hunting if deer numbers declined.

Commentors expressed a need for detailed baseline information describing existing socioeconomic conditions, potential impacts of a nonlocal work force on those conditions, and questioned whether those impacts would be mitigated.

1.6.1.16. Power Sales and Energy Resources

Comments included questions about whether the power generated would be locally used or exported and how much power would be contributed by the project to the region. A question was also raised about Midstate Electric Cooperative's (Midstate's) expected load and growth.

Other questions included whether other energy sources and conservation would be considered and whether cumulative impacts of new energy sources would be addressed.

There were comments supportive of geothermal power, and questions about the transmission line size, location, and impacts.

1.6.2. How Were the Issues Incorporated into the EIS?

Some of the issues described above were considered to be "key issues" and were used to generate the alternatives. For example, alternatives include different power plant, road, or transmission line locations to respond to concerns about impacts on visual quality. Other issues were addressed through mitigation or monitoring or elsewhere in the EIS. For example, visual impacts of the power plant and pipelines might be mitigated by constructing them of materials colored to blend in with the background. Potential blockage of passage of wildlife and recreationists by the pipelines could be eliminated through construction of expansion loops large enough for these users to pass under. Issues that can be addressed through monitoring include monitoring of air quality at the plant site and at other sites, such as within the caldera, to ensure that pollution is not a problem.

Other issues raised were not within the scope of this EIS — such as alternative forms of energy or alternative locations — and could not be analyzed in this document. These issues are identified in the Scoping Report.

1.6.3. How Does the Project Relate to the Newberry National Volcanic Monument?

The Newberry National Volcanic Monument Act (PL 101-522), approved by Congress on November 5, 1990, established the NNVM and is the basis for future management of the lands described in the Act. The Act is the culmination of hard work and consensus reached by a diverse group of citizens who envisioned a National Monument at Newberry. The Act describes various categories of land within and around the actual NNVM boundaries, including the Special Management Area and nearby geothermal leases, which have application to this proposed geothermal project. A considerable portion of the Legislation describes if, how, or when geothermal activity can occur on specified areas. A brief summary of elements of the Act that are most pertinent to this geothermal proposal are described below. Figure 1.3-3 shows the project location with respect to the Monument boundary and Special Management Area.

Monument. Federal lands within the Monument are withdrawn from all forms of entry or disposition under geothermal leasing laws. This means there will be no geothermal lease activity within the Monument boundary. This includes drilling under the Monument from locations outside the Monument boundary.

Special Management Area (SMA). Geothermal leases issued in this area will contain stipulations that prohibit surface occupancy. The SMA can only be entered by directional drilling from outside the SMA boundaries. This means that although SMA lands can still be included in geothermal leases, no surface activity can occur. Operators could reach geothermal resources under the surface if drilling initiates on authorized leases outside the SMA.

Management Outside The Boundaries Of The Monument. Nothing in the Act authorizes or directs the establishment of protective perimeters or buffer zones around the Monument or SMA for the purpose of precluding activities outside the boundaries which would otherwise be permitted. The fact that activities or uses outside the Monument and SMA can be seen, heard, measured, or otherwise perceived within the Monument and SMA shall not, of themselves constitute grounds for limiting, restricting, or precluding such activities up to the boundary of the Monument and SMA. In other words, Monument status should not be viewed as placing additional management constraints on adjacent Federal lands. Additionally, except as provided elsewhere in the Act, nothing in the Act shall be construed to affect the authority of the Secretary of Interior (delegated to the BLM) to administer geothermal leases.

The Act also has provisions covering Federal geothermal leases which were issued within the Monument's boundary prior to the legislation. The Act required that all existing lease holders relinquish all rights to these leases. In exchange for relinquished leases, new leases of like value were issued as compensation to the affected lease holders. These new leases are for lands outside the NNVM, although some leases include lands within the SMA, and are consistent with Forest policy and management. Specific leases are listed in the legislation, and include the leases held by CEE and proposed in this geothermal project.

Another element affecting this geothermal proposal is that the Monument Act gives the Secretary of Agriculture (delegated to the U.S. Forest Service) authority for regulating all surface disturbing activities and approval of the Plans of Operation for leases issued under the Act. By this provision, the Act ensures that the effects of the proposed operations can be considered on the values for which the Monument and SMA were established. Without this provision, the BLM would be solely responsible for approval of the Plans of Operation, which is the case in all other Federal geothermal leases.

2.0
ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This section of the EIS includes a discussion of the:

- Range of alternatives
- Alternatives development process
- Alternatives considered but eliminated from detailed study
- Alternatives considered in detail
- Description of the alternatives
- Comparison of alternatives considered in detail (matrix and discussion)

The effects of the two "action" alternatives — Alternatives A and B — are summarized in Section 2.5. The affected environment is described in Chapter 3. The effects of implementing the alternatives are discussed in Chapter 4.

2.1. RANGE OF ALTERNATIVES

The range of alternatives to the proposal submitted by CEE is limited to those alternatives that meet the purpose and need (see Section 1.2) for the proposed action. The range of alternatives is defined by certain limitations related to the project. For example, the proposed CEE Newberry project is being considered in order to demonstrate whether geothermal energy at Newberry Volcano can provide a reliable, economical, environmentally acceptable, and technically feasible alternative source of electricity for the public. For a potential pilot project, BPA selected a proposal submitted by CEE and EWEB for a geothermal development project at Newberry on specific leases. The reasonable alternatives are therefore limited to geothermal projects on CEE geothermal leases at Newberry.

To meet the purpose and need for the project, and to be within the scope of this analysis, the alternatives need to describe a project that is:

- A geothermal exploration and development project
- Located on areas under lease to CEE on the west flank of Newberry
- Located in areas with the geologic probability of encountering the geothermal reservoir fractures through vertical or slant (directional) drilling
- Located in areas that could accommodate the proposed facilities (wells, pipelines, power plant, transmission line) with sound engineering and environmental practices
- Designed to use technically feasible power generation technologies

Section 2.3, Alternatives Considered but Eliminated from Detailed Study, describes some of the alternatives (such as other power generation technologies) that are considered to be beyond the reasonable range of alternatives.

Alternatives that are considered in this document respond to issues of concern that were raised during the public scoping process and the environmental impact analysis process. Meeting the purpose and need narrows the range of alternatives to those relating to alternate locations for project facilities (such as the power plant site and transmission line) on the CEE leases, and modifications to the project design. This range addresses the issues raised and meets the purpose and need.

2.2. ALTERNATIVES DEVELOPMENT

In developing alternatives to the CEE proposal (Alternative A, described in detail in Section 2.4.1), the focus was on reasonable alternatives that would respond to identified issues, meet the purpose and need for the project, and eliminate or reduce adverse effects of these actions upon the quality of the environment (40 CFR 1500.2(e)). Reasonable alternatives are considered to be those that are practical or feasible from a common sense, technical, environmental, and economic standpoint. The alternatives were developed to be reasonable and feasible, meet the purpose and need, respond to issues, provide siting flexibility, and minimize environmental effects.

Each key issue that was identified during the public participation and scoping process (Section 1.6) was considered in the development of alternatives to the CEE proposal. The various elements of the project (facility locations, design elements, etc.) were reviewed after scoping to determine if alternatives could be developed that would respond to issues and reduce environmental effects. Alternative B was developed to analyze:

- Other potential drilling locations
- Alternate power plant sites
- Large well pad and power plant siting areas
- Alternate transmission line route
- Alternate transmission line design and construction methods

Another step in the development of alternatives was to review the mitigation measures built into Alternative A (where applicable). Additional mitigation measures identified in the analysis of Alternative A were incorporated into Alternative B to reduce environmental effects and respond to the issues.

Alternatives that did not meet the purpose and need for the project, that were not technically feasible, or that did not address the issues raised during the scoping process, were eliminated from detailed consideration in the EIS and are described in Section 2.3, Alternatives Considered but Eliminated from Detailed Study. Each of the alternatives considered was reviewed for consistency with the purpose and need and the issues.

2.3. ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

The lead and cooperating agencies have considered alternatives throughout the EIS process, including evaluation of issues raised in the scoping process and during the development of the EIS. CEE considered a variety of alternatives in developing its proposal. Some of the alternatives proposed during the public scoping process were not given detailed analysis in the EIS because they would not meet the purpose and need, would be beyond the scope of this analysis, had been considered in another EIS or Environmental Assessment (EA) (such as the Bonneville Power Administration's Resource Programs EIS [Bonneville Power Administration 1993d]), would not be technically feasible, or would have greater adverse environmental effects than would the original proposed project. Alternatives that were considered but not given detailed study in this EIS include:

- Alternate power generation technologies

- Alternate geothermal power generation technologies
- Alternate transmission technologies
- Alternate locations beyond the CEE leases

The alternatives eliminated from detailed study are summarized below.

2.3.1. Alternative Means of Increasing Available Power or Decreasing Demand

2.3.1.1. Solar and Wind Power

Solar and wind power development were suggested as an alternate technology to meet power demand. This alternative is outside the scope of this EIS because the intent of the project is to demonstrate whether geothermal energy at Newberry can provide a reliable, economical, environmentally acceptable, and technically feasible alternative source of energy. A wind or solar project would not meet the purpose of confirming the existence and the capacity for development of high-potential geothermal reservoir at Newberry and is beyond the scope of this EIS.

2.3.1.2. Produce Electricity from One Small-Diameter Well/Smaller Power Plant

An alternative proposed during scoping was to use only one well that is 3 cm (1.25 inches) in diameter, and to produce electricity from a generator that is approximately the size of a pickup truck.

This alternative was not considered in detail in the EIS because it does not meet the intent of the pilot project. Electricity production from one well that is 3 cm (1.25 inches) in diameter would not be adequate to determine the commercial viability of the resource, or meet the purpose and need for the proposed action. A production well of this size would not be technically feasible, especially at the depths (over 1,219 meters [4,000 feet]) at which the geothermal reservoir at Newberry is expected to be encountered.

2.3.1.3. Raise Utility Rates to Control Electricity Demand

Raising electric rates to decrease demand was suggested as an alternative to the proposed action.

This analysis is beyond the scope of this EIS and does not respond to the purpose and need for the proposed action. This EIS does not address alternatives involving ways to reduce demand.

2.3.2. Alternative Locations

2.3.2.1. Proposed Project on Private and Non-Forested Lands

A comment was submitted during the scoping period that proposed that the geothermal development should take place on private and non-forested lands.

CEE proposes to determine the existence and commercial viability of the Newberry geothermal resource through drilling and operation of a 33-MW geothermal resource. Geologists have identified Newberry Caldera and the surrounding area as being the most likely location to encounter the geothermal resource. The private lands within the Newberry Known Geothermal Resources Area (KGRA) are not suitable for the proposed geothermal development. Unlike traditional power plants, geothermal development and utilization can only occur where the resource is located. Leases have been offered and made available in these high-potential areas.

This alternative was not considered because it does not meet the purpose and need and is not technically feasible.

However, the use of non-forested lands or areas previously logged or disturbed within the CEE leases will be considered in the EIS as potential site locations for project facilities.

2.3.2.2. Effects of Power Generation Facility that Would Be Built Elsewhere

During scoping, an interested party suggested that the comparative effects on the environment as a whole be addressed in the EIS because the no-action alternative would result in some other alternative form of energy development occurring at another location. This analysis is beyond the scope of this EIS because it does not meet the purpose and need.

2.3.3. Alternative Geothermal Power Technologies

There are several different technologies for tapping the energy from geothermal resources. The different types of geothermal power plants include binary, single-flash, double-flash, and pure steam technologies. Since each geothermal resource has unique characteristics, some technologies are not technically appropriate or feasible for a given location. Certain technologies were eliminated from further study either because they are not the most effective technology for the Newberry project or because they are technically not feasible for the resource.

2.3.3.1. Binary Plant

Binary-cycle power plants are usually used to produce power from shallow, low temperature (less than 177°C [350°F]) geothermal resources. Binary plants use geothermal fluids to heat a secondary fluid (usually a hydrocarbon such as isobutane or isopentane) that vaporizes at a lower temperature than water. Current studies (see Section 3.4, Geothermal Resources) indicate that the resource temperature at Newberry will be above 177°C (350°F) and is expected to include both steam and hot water. In a binary plant, the brine would have to be kept under pressure to keep it from flashing to steam. The additional electrical load from pumps, coupled with other considerations, indicates that a binary plant would be a technically inappropriate and energy-inefficient use of the geothermal resource at Newberry. Also, the hydrocarbons used in a binary plant create environmental concerns related to fugitive emissions and the transportation and storage of petrochemicals. Unless dry (fan-forced air) cooling is used, ground or surface water must be used in the condenser. Dry cooling imposes an additional electrical load on the plant, and is inherently less efficient because cooling efficiency (and therefore plant output) depends on ambient air temperature. Therefore, a binary plant is not addressed in detail in this EIS. If, during exploration, resources are discovered which are suited to binary technology, then a new analysis will be prepared.

2.3.3.2. Single-Flash Plant

A single-flash plant would not be a technically feasible alternative because it would not optimize the use of the geothermal resource. In a double-flash plant, as proposed, the steam and hot water are separated at the well head, and the separated hot water is allowed to flash to steam at high pressure and again at a lower pressure. This double-flash process increases the amount of steam that can be extracted from the resource and therefore maximizes the amount of electricity that can be produced from a given volume of reservoir fluid. A single-flash plant would be less efficient in tapping geothermal energy than a double-flash plant, but would be expected to result in similar environmental effects. This alternative, therefore, will not be addressed in detail in this EIS.

2.3.3.3. Pure Steam Plant

A pure steam plant can only be used with a geothermal resource that produces only steam and no hot water. There is currently only one known dry-steam geothermal resource in the United States, at The Geysers in California, and only three other locations are known in the world. The geothermal resource at Newberry is not expected to be a dry-steam resource so this technology is not addressed in detail in the EIS. Dry steam plants typically "consume" on the order of 80 percent of geothermal fluid as evaporative loss in the cooling tower (Lake County 1989). This fluid is not available to replenish the reservoir. If, during exploration, resources are discovered which are suited to pure steam technology, then a new analysis will be prepared.

2.3.4. Transmission Line Alternatives

2.3.4.1. Lower or Higher Voltage Transmission Line

The transmission line voltage of 115 kV was selected because it is an industry standard and is an efficient voltage for the level of power (33 MW) proposed. This voltage would also allow the proposed transmission line to connect directly to a Midstate Electric line (which is 115 kV). Lower voltages were rejected because:

- Lower voltages have higher line losses of electricity.
- Midstate Electric may operate or own the transmission line, the line from the project would connect to a 115-kV line, and a different voltage would increase operation and maintenance costs.

The next lower voltage is 69 kV. A line of this voltage would have significantly lower capacity than the 115-kV voltage and would have limited capacity to carry additional power should significantly more than 30 MW be developed. In addition, a 69-kV line would require similar size structures as the 115 kV, with substantially similar environmental impacts.

A transmission line at 230 kV would have larger capacity, but would be more expensive and would not be compatible with Midstate's system. The proposed 115-kV line would accommodate the proposed project and its foreseeable expansion. The alternative 230 kV was not considered because it exceeds the requirements of the project as proposed as well as any foreseeable expansion as envisioned in the contracts for power sales between CEE EWEB, and BPA.

2.3.4.2. Alternative Transmission Line Routes

Prior to submitting, CEE evaluated eight possible transmission line routes to transmit power from the proposed power plant to the existing transmission line grid in the region. The alternative routes were considered but eliminated from detailed consideration because they (1) required a crossing of Paulina Creek (which could interfere with a wild and scenic river designation), (2) cross the Peter Skene Ogden Trail, (3) cross through the old growth area near Paulina Creek, and/or (4) require many more new roads and more extensive road construction.

2.3.4.3. Buried Transmission Lines

The potential for using buried transmission lines has been raised by the public. Although an underground system was not reviewed in detail, engineers concluded that underground transmission lines were not warranted or economical. Construction-related environmental impacts from underground transmission systems in wooded, rocky terrain would generally be greater than for conventional overhead systems.

The following discussion is based on internal review completed at EWEB for underground transmission systems:

- Installation requires that a continuous path be cleared for the cable trench. This often causes greater environmental impacts than an overhead line.
- The estimated costs for installation of approximately 13.1 km (8.2 miles) of underground 115 kV for the Newberry project is estimated to be between \$8 million and \$11 million while the estimated cost for installation of the same amount of an above-ground system is about \$2 million.

- Operation and maintenance costs for these systems are significantly higher than for equivalent overhead systems. Vaults for splicing and cable pulling are required every 305 to 457 meters (1,000 to 1,500 feet) and must be kept clear for maintenance.

- Underground transmission circuits are normally used in congested urban settings in larger metropolitan areas. Rural applications are rare and are not considered to be as cost-effective as overhead.

- Cable faults on underground systems require more time to locate and repair than with overhead circuits. The systems owner is generally required to maintain significant surplus cable for replacement since manufacturing time is long.

- Complete installation costs for an underground 115-kV transmission circuit are estimated at several times the cost of equivalent overhead circuits. Installation in wooded forest areas with rocky conditions, access limitations, and additional travel time would further increase costs.

- Highly trained personnel are required for installation, including make-up of splices and terminations. Some utilities are beginning to use a solid dielectric cable that is also large in diameter, limited in flexibility, and requires specially trained personnel for installation.

Operation and maintenance costs for underground 115-kV systems are significantly higher than equivalent overhead systems. Winter conditions at the project area would make repair and maintenance exceptionally difficult and time consuming. Down-time would be extended and that could significantly impact the on-line time of the power plant.

There are a variety of conductor sizes for 115-kV systems. CEE sized the conductors and facilities to allow for the potential for incremental increase in power without the addition of a second transmission line. An underground system does not allow for economical installation of larger conductors or the option of reinsulating the line to convert to a higher voltage to allow for future incremental growth.

For all of the above reasons, an underground 115-kV transmission system was not given detailed study in this EIS.

2.4. ALTERNATIVES CONSIDERED IN DETAIL

The purpose of looking at other alternatives is to describe the opportunities and trade-offs of different approaches to help the lead and cooperating agencies make reasoned decisions. The alternatives considered in detail in the EIS fall into two basic categories:

- Siting variations

- Design variations

The alternatives include siting for various components of the proposed project (transmission line, well pads, roads, pipelines, and power plant) and design alternatives that reduce or eliminate the environmental impacts of these roads and facilities. Alternatives also include constraints such as construction, operation, and maintenance.

Three alternatives are presented, as follows: Alternative A, Alternative B, and Alternative C (the no-action alternative). These alternatives are discussed below. Table 2.4-1 shows features of Alternatives A and B. Alternative B can be considered as a modification of Alternative A.

Table 2.4-1 Features of the Proposed Action Alternatives[1]

Project Element	Alternative A	Alternative B
WELL PADS		
[2]Pad size Temperature gradient hole/core hole	18.3 x 30.5 meters (60 x 100 feet)	18.3 x 30.5 meters (60 x 100 feet)
Production/exploration size	Up to 121.9 x 182.9 meters (400 x 600 feet) per pad or up to about 34 hectares (84 acres) total	121.9 x 182.9 meters (400 x 600 feet) per pad within a 16.2-hectare (40-acre) siting area; up to about 34 hectares (84 acres) total
[2]Sump	3,785,000 liters (1 million gallons)	3,785,000 liters (1 million gallons)
WELLS		
[2]Temperature gradient	4 temperature gradient wells	4 temperature gradient wells
Exploration	Up to 28 exploration wells[3] at 14 locations	Up to 28 exploration[3] wells at 14 of 20 locations
[2]Production	Initially 8 to 104 (plus additional wells over the life of the project)	Initially 8 to 104 (plus additional wells over the life of the project)
[2]Injection	3 to 5	3 to 5
[2]Testing	Up to 90 days per well	Up to 90 days per well
NEW ACCESS ROADS		
Access to power plant and well pads (excludes 1.9 kilometers [1.2 miles] of existing Road 9735)	Main access road to power plant: 18.3 meters x 3.3 kilometers (60 feet x 2.05 miles) (Includes part of transmission line ROW along power plant access road.) Well pad access roads: 6.7 meters x 4.8 to 6.4 kilometers (22 feet x 3 to 4 miles) Total surface disturbance for new access roads about 13.5 hectares (33.5 acres)	Main access road to power plant: 18.3 meters x 3.3 kilometers (60 feet x 2.05 miles) (Includes part of transmission line ROW along power plant access road.) Well pad access roads: 6.7 meters x 4.8 to 6.4 kilometers (22 feet x 3 to 4 miles) Total surface disturbance for new access roads about 13.5 hectares (33.5 acres)
PIPELINES		
Production and injection pipeline corridors	Main Pipelines: 36.6 meters x 6.1 kilometers (120 feet x 3.8 miles) = 22.7 hectares (56 acres)[5] Feeder Pipelines: 13.3 hectares (33 acres)	Main Pipelines: 36.6 meters x 6.1 kilometers (120 feet x 3.8 miles) = 22.7 hectares (56 acres)[5] Feeder Pipelines: 13.3 hectares (33 acres)
POWER PLANT SITE		
Siting location	7.5 hectares (18.5 acres) One possible location	7.5 hectares (18.5 acres) site within one of three 12.1-hectare (30-acre) siting areas

Table 2.4-1 Features of the Proposed Action Alternatives[1] (Continued)

Project Element	Alternative A	Alternative B
POWER PLANT DESIGN		
[2]Cooling towers	7-cell wet cooling towers	7-cell wet cooling towers
[2]Water use	Local groundwater (up to 3.08 million m^3 [2,500 acre-feet]) per year and produced geothermal fluid (approximately 1.9 million m^3 [1580 acre-feet]) per year	Local groundwater (up to 3.08 million m^3 [2,500 acre-feet]) per year and produced geothermal fluid (approximately 1.9 million m^3 [1580 acre-feet]) per year
[2]H_2S removal	Liquid redox, iron catalyst or hydrogen peroxide	Liquid redox, iron catalyst or hydrogen peroxide
TRANSMISSION LINE		
Route	North and adjacent to Road 9735	South of Road 9735
Poles	Wood pole, H-frame	Single wood pole with underbuild
[2]Voltage	115 kV	115 kV
Disturbance	30.5 meters x 13.1 km (100 feet x 8.2 miles) = 40 hectares (99 acres) (with additional 25 to 50 feet feathered for 8.2 miles)	22.8 meters x 13.1 km (75 feet x 8.2 miles) = 30 hectares (75 acres) (with additional 50 feet x 8.2 miles feathered)
ROW clearing	30.5-meter (100-foot) width cleared 7.6 meters (25 foot) width feathered on one or both sides of ROW	22.9 meter (75 foot) width cleared 7.6 meters (25 foot) width feathered on both sides of ROW
[2]Laydown/construction areas	Existing log landings	Existing log landings

[1]Alternative C - No Action: None of these features would be built.
[2]Features that are the same in both alternatives.
[3]Some of these wells would be converted to production wells.
[4]Some of these wells would be converted from exploration wells to production wells.
[5]This is the width required for multiple expansion loops. A more typical width would be 27 m (90 ft) or less.

Alternative B, the agencies' preferred alternative, includes additional means of meeting the purpose and need of the project, based on the agencies' response to the analysis and to issues raised during the scoping process, with additional siting flexibility designed to minimize potential environmental effects. Alternative C is not included in the table because it would not include any of the alternate project elements described in the table. The affected environment is described in Chapter 3. A review of potential impacts and mitigations for each of these proposed alternative plans is presented in Chapter 4.

2.4.1. Alternative A

CEE proposes to build and operate a geothermal electric power plant and supporting facilities capable of generating 33 MW (gross output) electric power. Of the 33 MW of gross output power, 30 MW would be salable at the BPA integration point at the LaPine switchyard and three megawatts would be consumed in operation of the power plant or lost through transmission line resistance. As described in Section 1.3.2.4, 20 MW and 10 MW would be sold to BPA and

EWEB, respectively, under power purchase agreements. BPA and EWEB would also enter into billing credit and wheeling agreements.

Facilities required for development of the project would include:

- A power plant at one proposed location
- Well pads and sumps
- Geothermal fluid and steam gathering system
- Steam separation vessels
- Exploration and production wells
- Access roads
- A water supply system
- Injection well system
- Noncondensable gas control system
- A power transmission line (that closely follows the north side of Road 9735)
- Switchyard
- Rebuilding of approximately 6 km (3.5 miles) of Midstate transmission line in LaPine from 6th Street west of Highway 97

The CEE proposal, or Alternative A, is described in this section under the framework of the four phases of the project: exploration, development, utilization, and decommissioning. The phases, their facilities, and the timing of the implementation of each phase are summarized in Table 2.4-2. Some of the facilities and activities would continue over more than one phase. For example, well pad construction and drilling would occur in the exploration phase, development phase, and operation phase as CEE continues to define the geothermal resource and provide production and injection capacity for the power plant. Figure 2.4-1 is a schematic representation of activities and facilities through the life of the proposed project. Table 2.4-3 shows the proposed project schedule.

The description of the proposed features of Alternative A is based on CEE's Plans of Operation for the project. The exploration, well drilling, and fluid production aspects of the project are described in the "Plan of Operations for Exploration, Development and Production" (CEE 1992a). Power plant construction, operation, disposal, and power transmission are described in the "Plan of Operations for Utilization and Disposal" (CEE 1992b).

2.4.1.1. Project Location

The proposed project power plant would be located in the Newberry KGRA on Federal geothermal leases. The proposed power plant facilities would be located in Section 21, Township 21 South, Range 12 East, Willamette Meridian. The proposed plant site is centrally located in relation to the proposed well field. The general location of the proposed project is shown in Figure 1.1-1. Drilling from surface locations on these leases into subsurface locations leases with No Surface Occupancy stipulations would also occur. Figure 1.3-3 shows additional details of the lease area and vicinity, highlighting the terms that are used through the rest of this EIS to describe various specific portions of the project area.

The terms "transmission line area," "lease area," "SO lease area," and "NSO lease area" are used to describe locations associated with this geothermal proposal and analysis and are depicted in Figure 1.3-3. "Transmission line area" includes the general area which would connect the power plant to existing transmission lines near Highway 97. Either of the proposed alternative transmission line routes would be within the "transmission line area."

Table 2.4-2 Project Phases, Facilities, and Timing

Phase	Facilities/Activities	Timing
Exploration	This phase includes the construction of access roads and well pads, and the drilling and testing of initial exploration (temperature gradient, core hole, and deep exploration) wells to identify the resource and determine its extent and physical characteristics (location, depth, temperature, pressure, chemical constituents, etc.)	Exploration could occur from initial project approval until well into the utilization stage, as the extent of the reservoir is defined.
Development	Construction of production well pads and access roads, pipelines, power plant, and transmission line; well testing and power plant testing.	Development activities would begin after exploration wells confirm the existence of an adequate geothermal resource to meet the proposed project's requirements.
Utilization (or Operation)	Testing and operation of the wells, pipelines, power plant, and transmission line.	May occur concurrent with some of the development operations (such as road, pad, and well construction).
Decommissioning	Removal of surface facilities, plugging and abandoning wells, reclamation.	Expected to occur at or beyond the end of the 50-year life of the contract with BPA if the contract is not extended. Some elements of the project may be decommissioned and replaced prior to the decommissioning of the entire project. The project life is not necessarily limited by the term of the power contract.

"Lease area" refers to Federal geothermal leases held by CEE, which are being considered for geothermal activity in this analysis. "SO lease area" refers to that portion of the leases where surface activity could be permitted. Such surface activity would include siting of the power plant, well pads, roads, and pipelines. The lease area also includes Special Management Area (SMA) lands, as identified in the NNVM legislation, where no surface occupancy would be allowed ("NSO lease area"). There would be no facilities or surface disturbance within this NSO lease area. However, it is important to understand that subsurface activity could be allowed to occur under the NSO lease area, such as by slanted drilling of the wells. In these circumstances, the well pad itself would be located within the SO lease area, but the well shaft would be drilled at an angle, so that the bottom of the well is below the surface of the NSO lease area. At no time, however, would any part of the underground well extend into the NNVM.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	General Activities During Project Phases	Figure 2.4-1

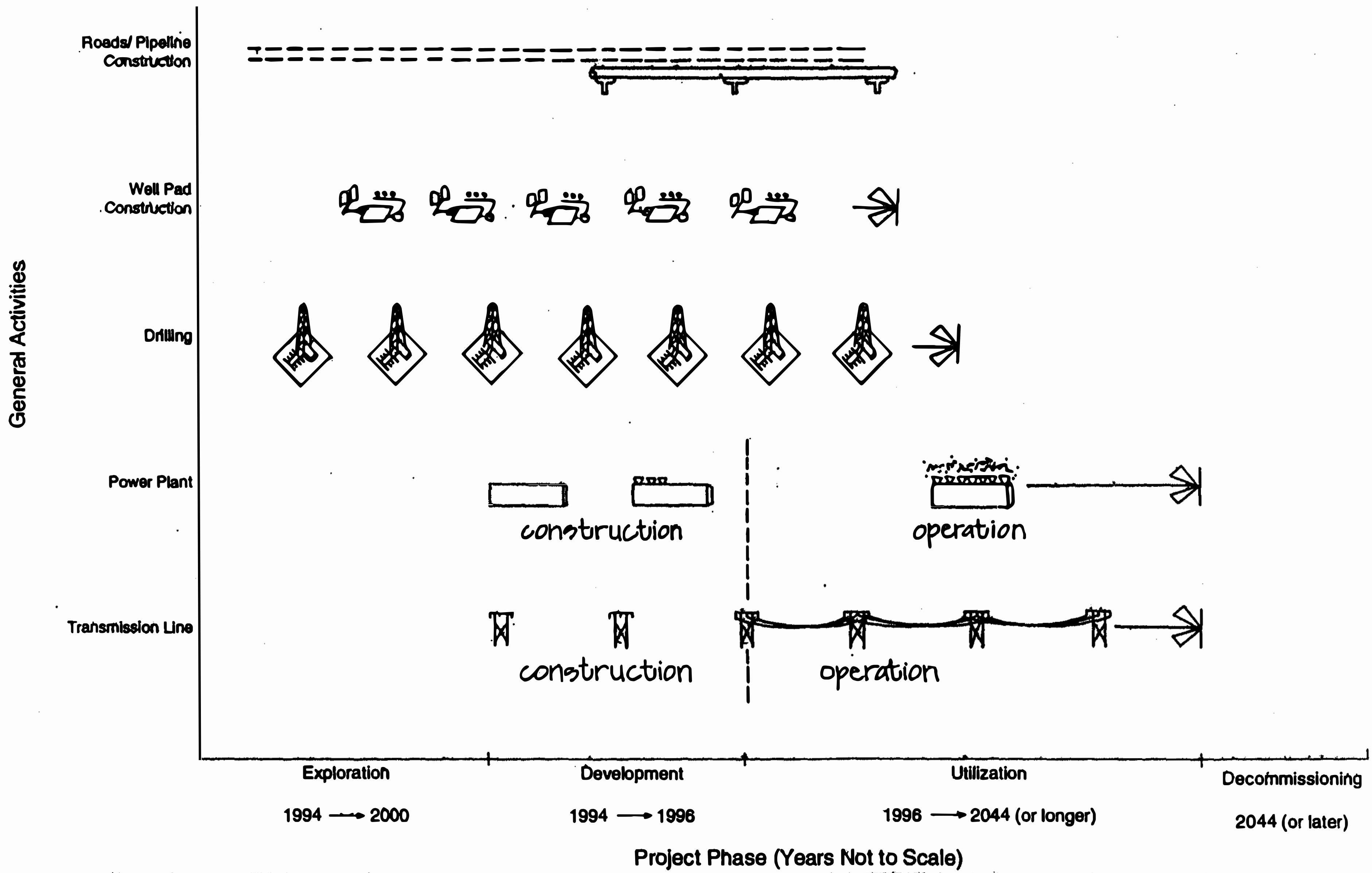


Table 2.4-3

Proposed Project Schedule

	1994						1995												1996										
Description	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Months from ROD	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EIS/Drilling Permits		■																											
State Permits			■	■	■	■	■	■	■	■	■	■	■	■															
EX Well #1, 2: Drilling (1 big rig, 1 small rig)			■	■																									
Test Well EX#1					■																								
Winter Break 1						■	■	■																					
EX Well #3, 4, 5 (2 big rigs, 1 small)									■	■	■	■	■	■	■	■													
Reservoir Report																■	■												
Plant Site Excavation																■	■												
Reservoir Testing												■	■	■	■	■	■												
Winter Break 2																		■	■	■									
Construct Transmission Line																					■	■	■	■					
Construct Power Plant																					■	■	■	■	■	■			
Production Well Drill/Test																					■	■	■	■	■	■	■		
Construct Pipelines																					■	■	■	■	■	■	■		
Engineering/Procurement													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Startup Operations																											■	■	
Commercial Operations																													■

T2.4-3SCHEDULE

Figure 2.4-2 shows the location of the plant site and proposed well locations relative to the lease boundary and the boundary of the Newberry Special Management Area. Figure 2.4-2 also shows (1) the proposed corridors for steam gathering facilities and the access roads within the proposed project area, and (2) the location of the proposed transmission line area. Figure 2.4-2b contains photos of the present condition of the proposed plant site in Alternative A.

2.4.1.2. Exploration

Exploration would encompass the construction of well pads and access roads, drilling of three types of test wells, and testing of the wells. The wells would differ in diameter, depth, and type of drill rig used to construct the well, depending upon the specific purpose of the well. All drillings contain essentially the same types of mechanical components, as illustrated in Figure 2.4-3. The drill rigs differ in size depending on the depth and diameter of the well. Larger drill rigs similar to those used in oil and gas exploration are used to drill the deep large-diameter exploration and production wells. Smaller drill rigs are typically truck mounted and similar to water well drilling equipment, and are typically used for the smaller diameter wells. The types of wells and their use are listed in Table 2.4-1 and described below in Table 2.4-4.

Temperature gradient wells, core holes, and exploration wells would be drilled in this phase and are described below. Production and injection wells would be developed under the development phase and are described under Section 2.4.1.3.

Temperature Gradient Wells. The initial exploration of the geothermal resource would involve the drilling of temperature gradient wells, also called slim holes or temperature gradient holes (TGH), to a depth of approximately 1,676 meters (5,500 feet). The drilling for each well would occur 24 hours per day over a period of 10 to 60 days. TGHs would be drilled at the same time as deeper exploration wells and could be drilled any time in the first years of exploration. As the field is defined, such wells could also be drilled to further define the extent of the resource.

These 20-cm (8-inch) diameter wells would be drilled with a small, truck-mounted drilling rig, similar to those used for drilling water wells. The wells would be drilled with a rotary rig using mud or air and foam to bring soil and rock cuttings to the surface. The cuttings and drill muds would be discharged to a small sump or reserve pit on the pad (drill pads are discussed below). Figure 2.4-4 shows a typical slim hole or TGH well.

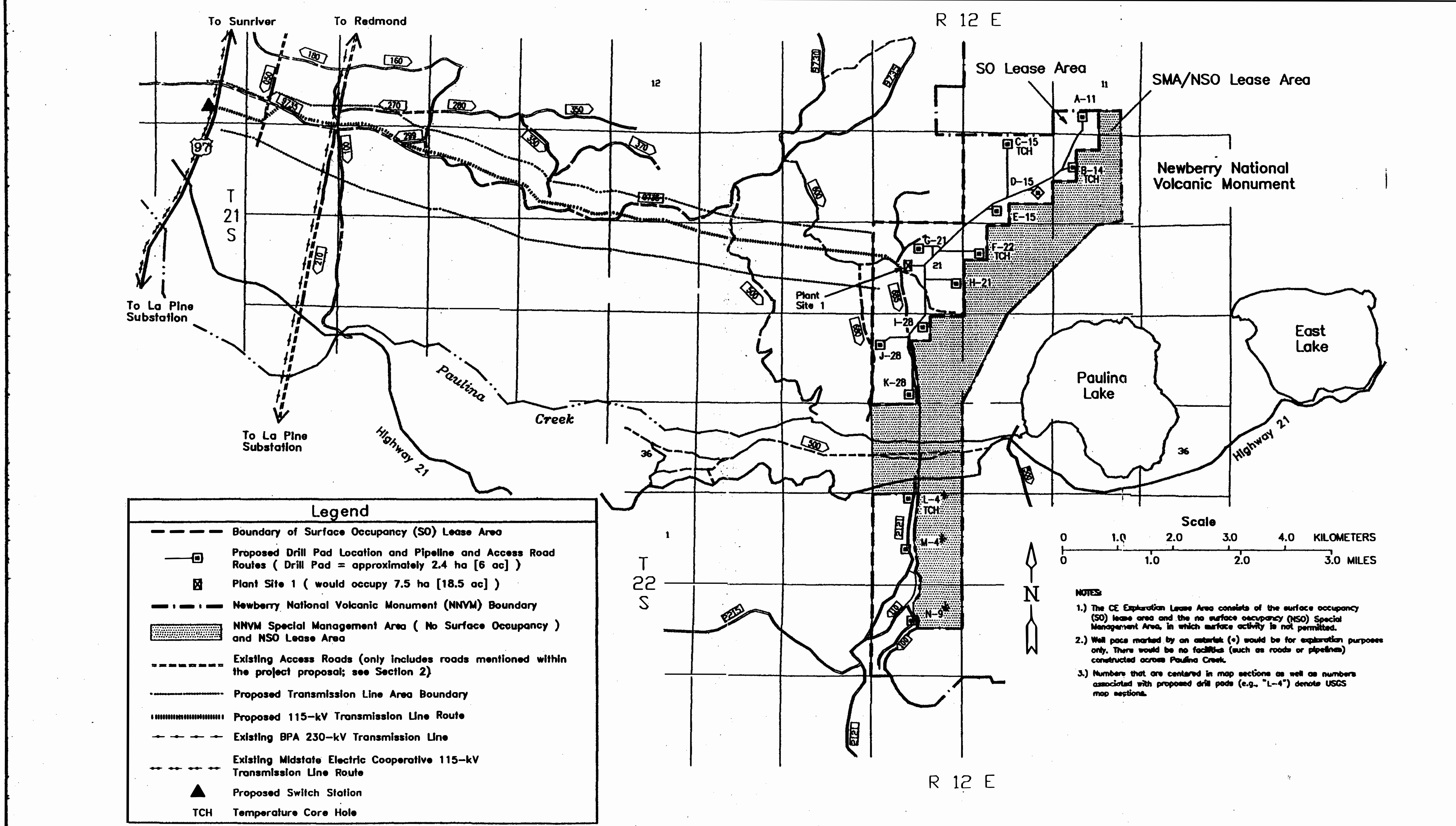
Core Holes. The temperature gradient wells and similar exploration-phase core holes can also be used to obtain cores of rock, which provide subsurface geologic information. These 11-cm (4.5-inch) diameter wells would also be drilled with a truck-mounted rig (see Figures 2.4-5 and 2.4-6). Core holes are not expected to be drilled into the actual geothermal reservoir. Core holes would be drilled to gather temperature and subsurface geologic information that would be used to determine the best location for exploration wells.

Exploration Wells. These wells would be used to evaluate and define the extent and characteristics of the geothermal reservoir within the proposed project area. The intent of the exploration phase is also to define the potential electricity production capacity of the geothermal resources. For the purposes of this EIS, the term "exploration wells" refers to wells capable of producing fluids to test the reservoir and, if successful, able to produce fluids to supply a power plant. The drilling for each well would occur 24 hours per day for 25 to 90 days. Exploration drilling would occur concurrent with TGH and core hole drilling, and would likely continue for several years. Exploration drilling could also occur during the development and utilization phases. Up to three exploration wells could be drilled at one time (in addition to the concurrent drilling of a TGH well), with an eventual total of up to 28 exploration wells.

NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

Alternative A, Newberry Geothermal Pilot Project

Figure 2.4-2



Plant Site 1. View is toward Paulina Peak.

FS Road 600 at Plant Site 1. View is toward northeast.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Components of a Rotary Drill Rig	Figure 2.4-3

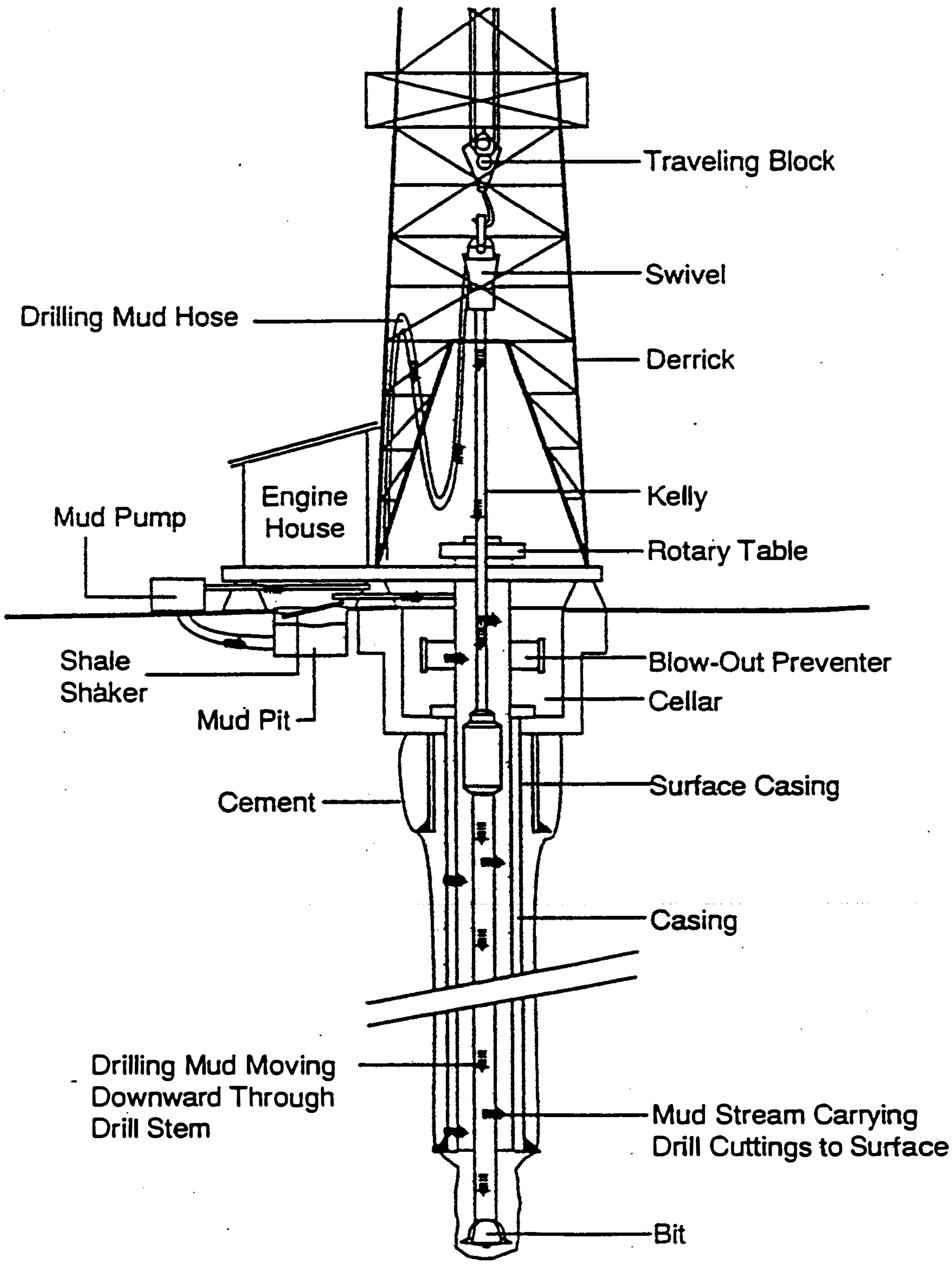


Table 2.4-4 Types and Purpose of Geothermal Exploration Wells

Type of Well	Purpose of Well
Temperature gradient well	Measure temperatures and temperature change at depth
Core hole	Obtain subsurface rock samples
Production-size exploration well	Sample and test the geothermal reservoir

Exploration wells would be drilled using a standard, oil and gas-type rotary drill rig (see Figure 2.4-3) to a depth of approximately 2,743 meters (9,000 feet). The wells would range in diameter from 34 cm (30 inches) at the surface to 24 cm (9.63 inches) to 18 cm (7 inches) at the bottom of the geothermal resource (see Figure 2.4-7).

It is anticipated that all exploration wells would be drilled at an angle (from the vertical axis) or offset (called directional drilling) from the surface location. In general, wells would be directionally drilled into the unoccupied, NSO lease areas adjacent to the well pad locations.

The exploration wells, if productive, would become production wells through the installation of pipelines connecting the well to the power plant (see Section 2.4.1.3).

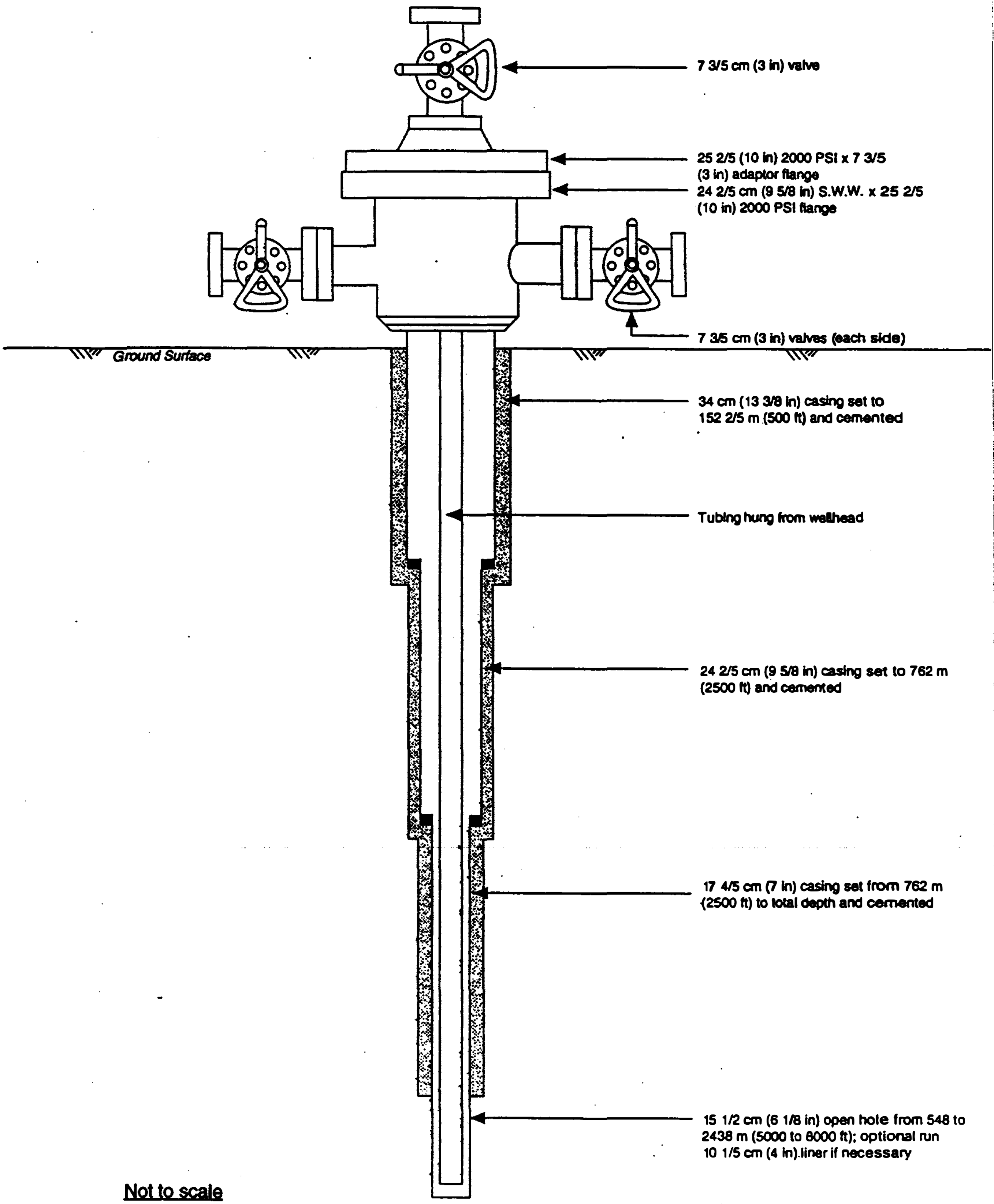
Well Pads. CEE has identified 14 potential areas for well pad construction. One 1.6- to 2.3-hectare (4- to 5.5-acre) well pad could be developed at each site. Well pads would be constructed as graded, level, and compacted surfaces with engineered cuts and compacted fill slopes. Pads would be designed to allow for drainage from the pad to be directed to the sump. Runoff drainage from pad areas outside of operating equipment areas would flow to natural drainages through erosion control devices. Well pad sumps would be fenced with 1.8-meter (6-foot) fiberglass fencing.

The exact location of each pad was based on CEE's analysis of the geological data to determine the best surface location necessary to drill the subsurface geological target. Up to four wells could be located on each pad. These 14 well pads would be the sites for test well (exploration) development, and for future conversion to production wells. No well pads additional to the original 14 are proposed for the production phase of this project.

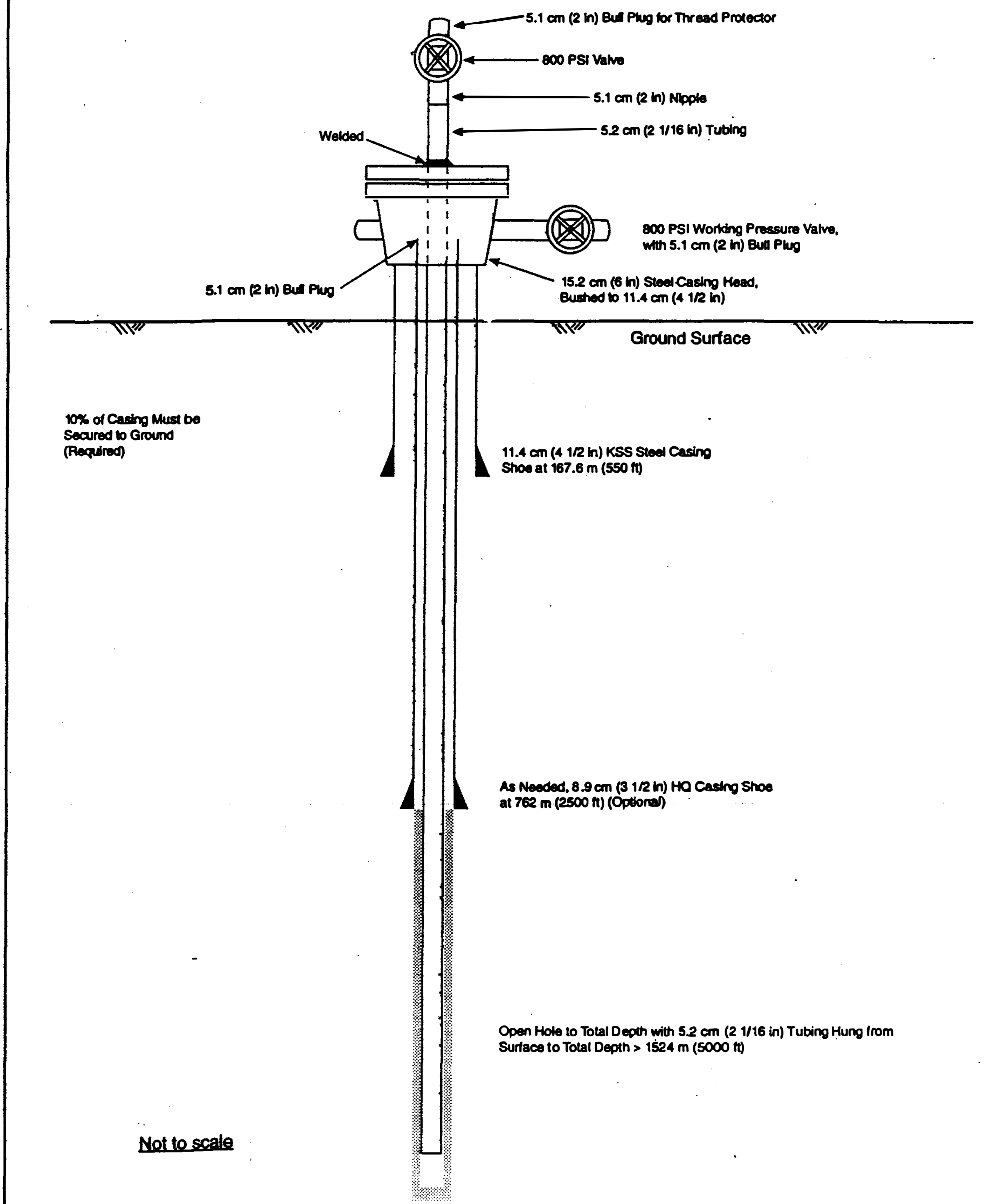
CEE has proposed the 14 locations for test well pads based on the results of initial review of the leases, regional structural geology, and work that was performed by the U.S. Geological Survey (USGS). The 14 locations shown in Figure 2.4-2 represent CEE's best estimate of exploration well locations, based on the information available at this time and the current understanding of the Newberry KGRA. To some extent, even wells drilled during the development stage can be considered to be exploratory in that the exact location of the fractures that would supply the geothermal fluid can be confirmed only through drilling.

The proposed well pads located south of Paulina Creek would be for exploratory purposes only. These wells would not become production wells under this project and no facilities would be built across Paulina Creek. South of Paulina Creek, six wells would be drilled under exploration on the three pads.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Slim Hole/Gradient Well	Figure 2.4-4

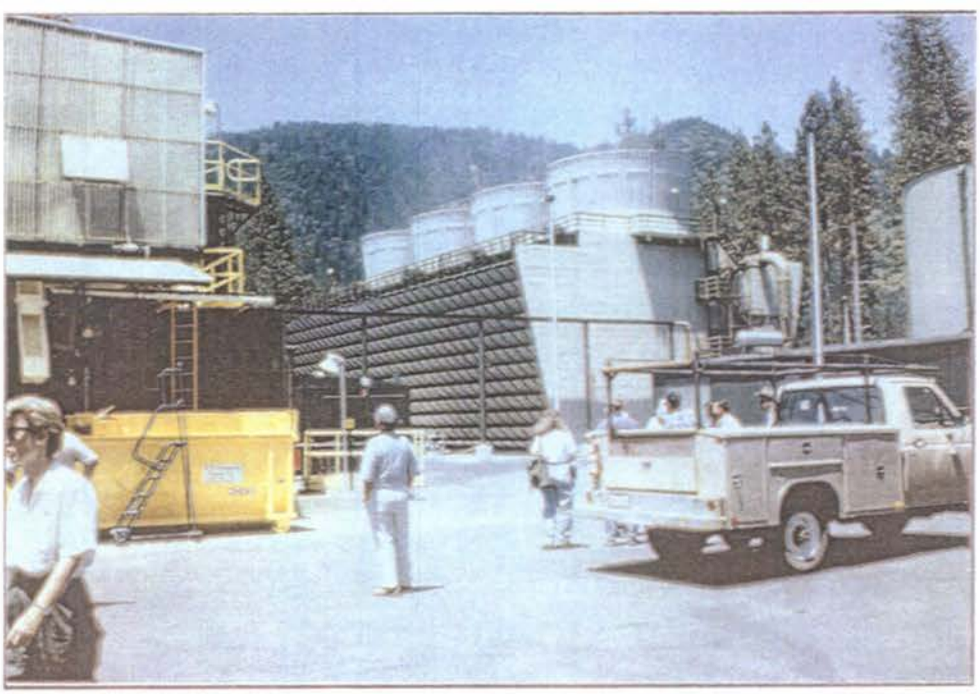


NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Core Hole/Gradient Well	Figure 2.4-5



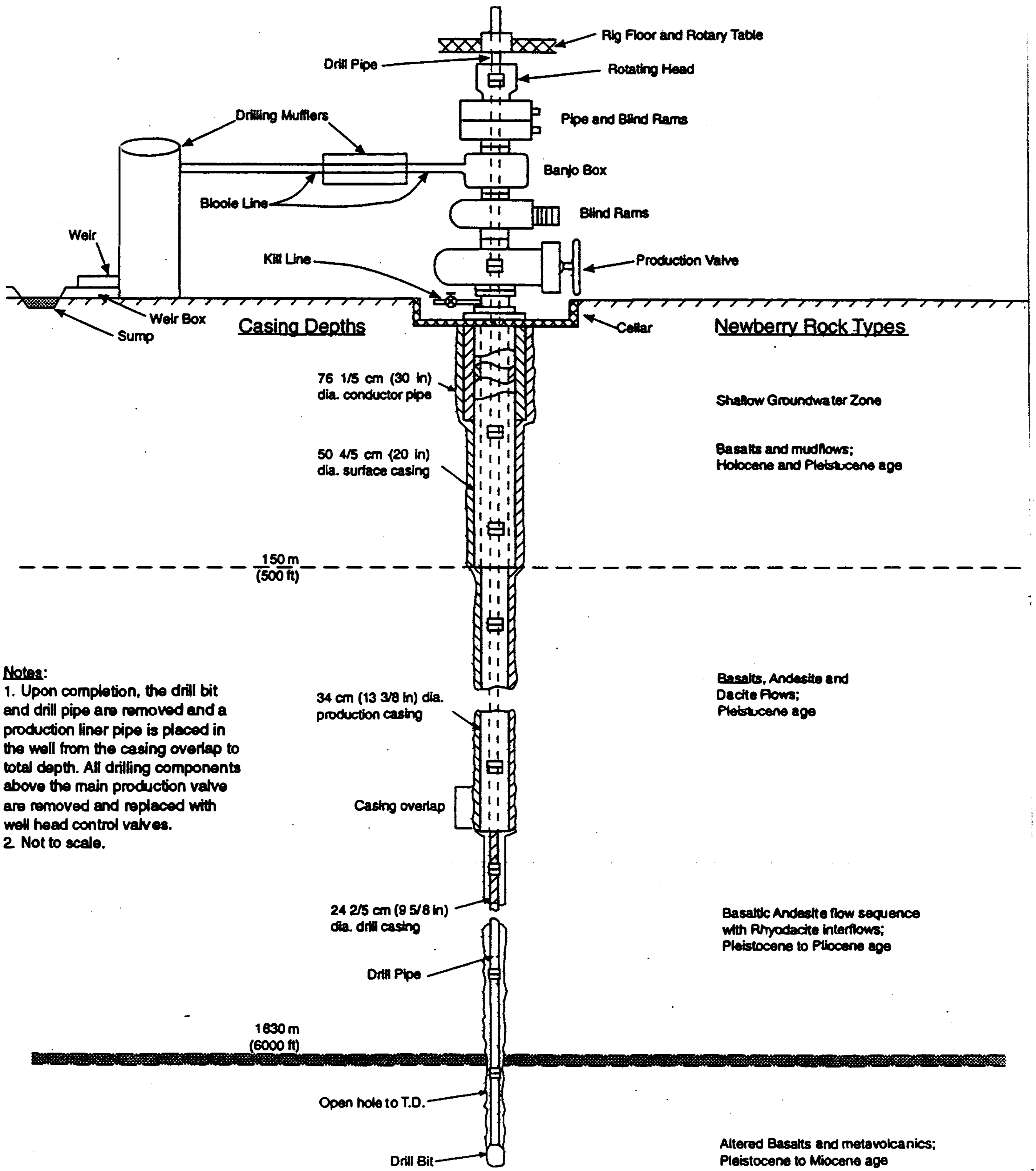
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Core Hole Drlg Rig and Power Plant Photos	Figure 2.4-6

Example of a core hole drill rig



Example of a state-of-the art geothermal power plant, picturing cooling towers in the center of the photoo

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Exploration/Production Well	Figure 2.4-7



Notes:
1. Upon completion, the drill bit and drill pipe are removed and a production liner pipe is placed in the well from the casing overlap to total depth. All drilling components above the main production valve are removed and replaced with well head control valves.
2. Not to scale.

It is anticipated that temperature gradient wells/core holes would be drilled at four of the exploration well pads. These smaller wells would be required to further delineate the boundary of the regional heat flow in the area and to prioritize the drilling. The temperature gradient wells/core holes would be constructed on 18 x 30-meter (60 x 100-foot) 0.06-hectare (0.14-acre) well pads. These temperature gradient well pads would be located in the corner of what could become a deep exploration well pad if the initial test results were successful. The layout and facilities of a typical temperature gradient pad and core hole pad are shown on Figure 2.4-8.

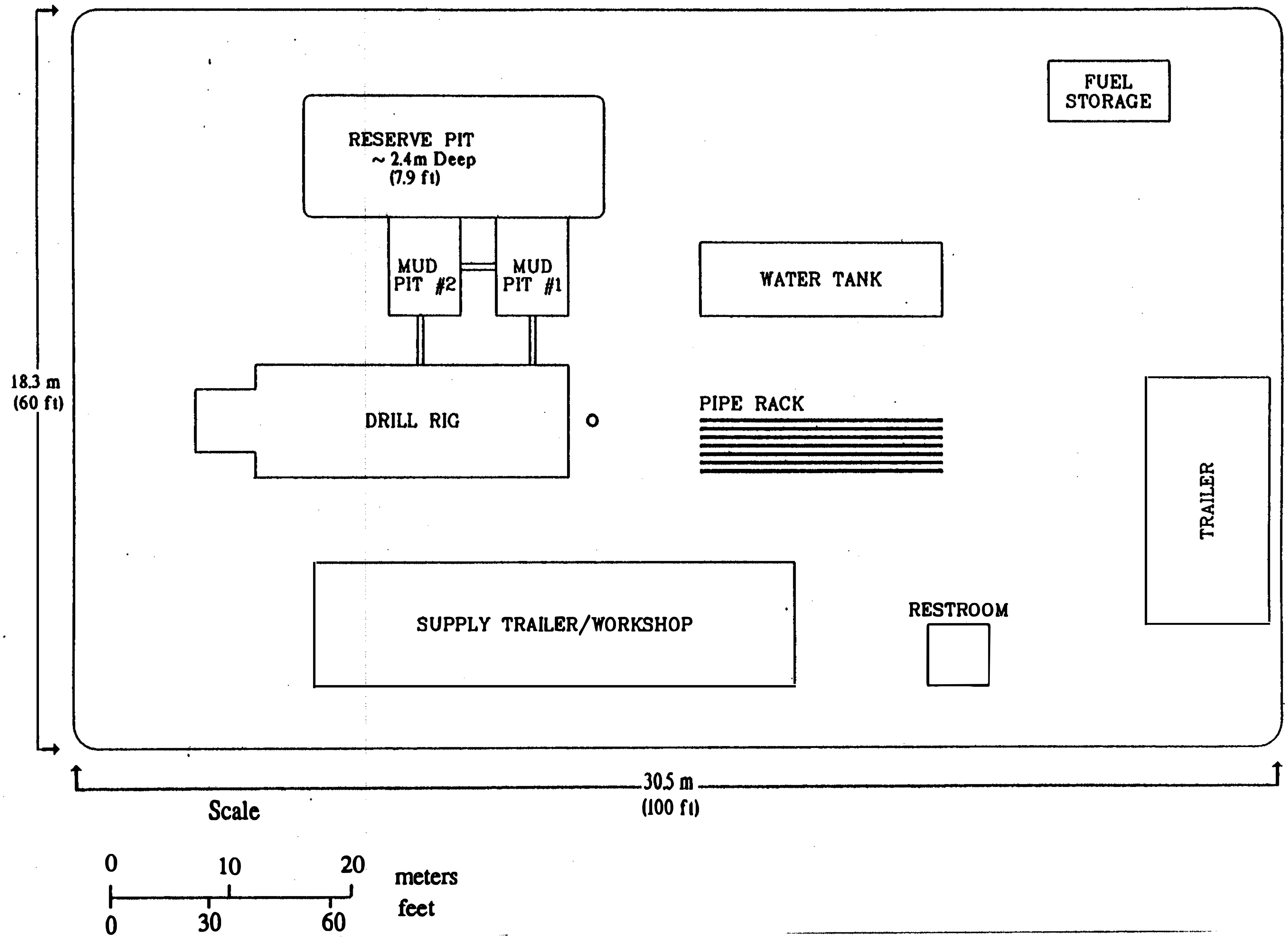
Production-size exploration well pads would be at least 122 x 122 meters (400 x 400 feet), or 1.5 hectare (3.67 acres) in size. Multiple-well pads could occupy up to 122 x 183 meters (400 x 600 feet), or 2.3 hectares (5.5 acres), including the associated cut and fill slopes. The size of the pads will be determined by the number of wells to be drilled on a pad, the size of the sump that is needed, and the size of the drill rig (the pad must be large enough to allow the assembly of the drill rig and the pad must be at least as long as the drill rig is high). Each exploration well pad would be considered a potential production well pad, if the exploration well is successful (with the exception of the three well pads south of Paulina Creek, which would not supply steam to the proposed plant under this proposal.) The layout and facilities of a typical exploration well pad are shown on Figure 2.4-9.

Sumps. Drilling of TGHs, core holes, and exploration wells requires a sump (or pit) to hold a water supply for drilling muds, soil and rock cuttings produced during drilling, and fluids produced from the geothermal resource. Each well pad would include one sump for the drilling of the wells on that pad. The sumps for the temperature gradient wells and/or core holes would be small pits of 3 x 7.6 meters (10 x 25 feet) surface dimensions and 2.4 meters (8 feet) deep. The 14 exploration well pads would each include a sump of approximately 122 x 46 meters (400 x 150 feet), adequately sized to hold a volume of 2,838,750 to 3,785,000 liters (750,000 to 1,000,000 gallons) of fluid and are expected to be large enough to accommodate well tests. Sumps would be compacted during construction and lined with clay. The small sumps constructed for TGH drilling would be reclaimed prior to construction of the larger well pad and drilling deep exploration wells on the same pad. If sumps approach capacity, fluids would be piped to another sump or injection well, or drilling or testing would be suspended until sump capacity became available. The on-site storage and disposal of mud slurry and wastewater will comply with ODEQ rules for degradation of natural surface and groundwater quality. If mud slurry or wastewater are transported off site, a Water Pollution Control Facilities or National Pollutant Discharge Elimination System permit will be sought. Sumps would be enclosed with 1.8-meter (6-foot) fiberglass fencing to keep wildlife away from fluids.

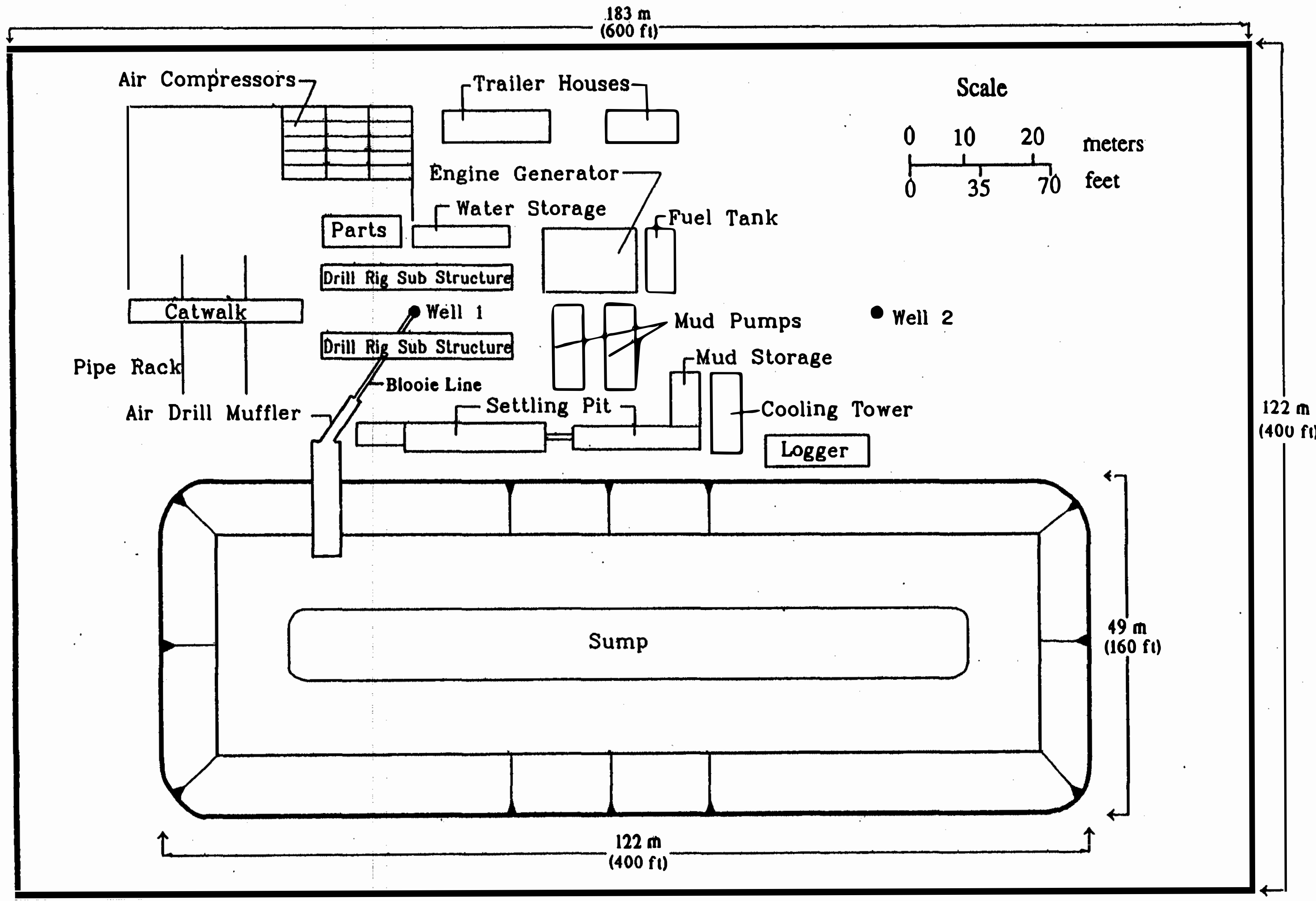
The contents of well pad sumps, including clay liners, will be tested for hazardous material levels prior to reclamation of the sump. If the contents are found to be hazardous, then the material will be disposed of at an approved licensed disposal facility. Quantities of sediments will depend on fluid chemistry (which is likely to vary somewhat between wells), how long wells are tested, the number of wells using each sump, and other factors that are not known at this time, but will be determined during the course of exploration. Multiple sump samples taken at Glass Mountain, Coso, Desert Peak, Roosevelt, and other hydrothermal resource sites throughout the Basin and Range and Cascade provinces have shown that sump contents are non-hazardous even after multiple years of use. The contents of these sumps are not expected to warrant a leak detection system or a lead detection system.

A minimum of 1 meter (3 feet) of freeboard will be required. The well pad sumps will not contain fluid most of the time, and will be pumped down prior to winter snow, and again to remove snow melt in the spring. Sumps will be bermed to direct storm water and snow melt away from the sumps, and the 1 meter (3 feet) of freeboard is sufficient to withstand a 100-year storm. Storm runoff from equipment operating areas will be directed into the sumps, whereas runoff from non-operating areas will be directed into natural drainages. A 2,838,750-liter (750,000-gallon) sump can accommodate 5 inches of runoff from a 5.5-acre pad, if the sump is empty at the time of the storm (as noted above, only a portion of the pad's runoff will be directed to the sump).

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Temperature Gradient and Core Hole Drill Pad	Figure 2.4-8



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Exploration Well Pad Layout (Top View)	Figure 2.4-9



Each production well is expected to produce approximately 180,000 kg (400,000 lb) of fluid and steam per hour. If the entire flow is fluid (this is a worst case — about a quarter of it will actually be steam), this will be about 190,000 liters/hour (50,000 gallons/hour). A 2,838,750-liter (750,000 gallon) well pad sump will thus take 15 or more hours to fill. Since a well can be shut down manually in two hours or less, the well pad sumps should be more than adequate to contain the flow.

Fluids stored in sumps would be injected or used for other approved uses such as road watering and construction compaction watering. These secondary (non-injection) uses will depend upon fluid chemistry and would require approval by the U.S. Forest Service, BLM, and Oregon Department of Environmental Quality.

Well Completion, Testing, and Abandonment. All drilling and completion operations would be in compliance with the Federal Geothermal Resources Operational Orders (GRO Orders)[1] and stipulations of Federal and state permits. The wells would include a steel casing to line the well and prevent percolation of drilling or geothermal fluids into any fresh-water aquifers. Exploration wells would have perforated casing or be open hole in the reservoir zone to allow geothermal fluids to enter the well. All drilling and casing programs would have prior approval of the BLM, to ensure that the GRO Orders and adequate safety margins are adhered to. No downhole production equipment (such as pumps) is planned, as the geothermal fluids are expected to flash to steam in the well bore and naturally flow to the surface.

Well testing would be expected to begin within 30 days of well completion. During this short-term testing (1 to 3 days), all liquids would be diverted to the sump, whereas steam and noncondensable gases would be vented to the atmosphere. Steam and produced fluid samples would be collected for analyses of chemical constituents and noncondensable gases.

If analysis were to show that the well had satisfactory commercial potential, well testing facilities would be constructed for long-term production testing. The entire test could be conducted within 30 days under ideal conditions. However, depending upon production characteristics, extended test periods of over 90 days could be required. Up to two wells would be tested at one time. The well testing emissions are described in Section 4.5, Climate and Air Quality.

If an exploration well did not exhibit economic production capability, it would be considered for use as an injection/disposal/reservoir maintenance well. If the well were to be abandoned, procedures would be in accordance with the terms of the GRO Orders and U.S. Forest Service specialists for rehabilitation of the site.

Analysis of well testing data would help to verify and define the type of power plant and facilities that would be appropriate for the type of geothermal resource. For example, chemical analyses would determine the hydrogen sulfide (H_2S) content of the gases. Each geothermal resource is unique and has its own chemical constituents. The well testing would verify assumptions made or identify the need for project modifications.

Water Sources. Water for drilling/coring activities would be trucked from private, shallow, cold-water wells. Where possible, water would be purchased from existing sources; however, CEE would secure state permits and drill water supply wells on leases controlled by CEE at a site approved by the authorized offices (the BLM and U.S. Forest Service) if necessary. All water withdrawal would be coordinated with, and subject to, the approval of the Oregon Department of Water Resources. If practical, temporary above-ground pipelines could be laid along existing roads or other appropriate routes from the water well to the drill site and between drill sites for short distances. Pipeline locations will require approval from Federal land managers.

[1] The GRO Orders were developed to provide guidelines for developing geothermal resources on federal geothermal leases, including drilling, testing, completion, abandonment, and environmental measures. They are used by the BLM in administering geothermal activity. BLM, as the manager of the federal geothermal resource, also reviews the drilling and casing program to ensure efficient use of the reservoir.

The proposed temperature gradient and core hole well drilling generally requires 11,400 to 18,900 liters (3,000 to 5,000 gallons) of water per day for 10 to 60 days for each well. Deep exploration wells would require 34,000 liters (9,000 gallons) of water per day for 25 to 90 days. In fractured zones, 75,700 to 151,400 liters (20,000 to 40,000 gallons) per day could be used. Fluids produced from successful wells would also be used, where practical and authorized by BLM and the U.S. Forest Service.

Well Pad Access Roads. All drilling sites would require road access for workers and equipment. All of the proposed drilling sites are located within 1.6 to 4.8 km (1 to 3 miles) of existing log landings, skid roads, or otherwise previously disturbed ground, which either have or had road access.

Access to the drilling pads north of Paulina Creek would be via Forest Service Road (Road) 9735 to Road 600 and Road 685. Approximately 4.8 to 6.4 km (3 to 4 miles) of additional roads would be necessary to access the proposed drill pads in Sections 14, 15, and 22, T. 21 S. R. 12 E. CEE proposes to extend the 600 Spur Road system during the exploration stage by building dirt-based roads similar to Road 600. These new roads would be functionally classified as single-lane roads with a design speed of 24 to 48 km (15 to 30 mph), a maximum grade of 8 to 16 percent, a travel way width of 3.7 meters (12 feet), and a minimum 6.7-meter (22-foot) right of way for horizontal clearance. Turnouts would be provided on single-lane roads for opposing traffic. Turnouts would be spaced between 213 to 305 meters (700 to 1,000 feet) apart, as appropriate for the terrain. The main access road and spur roads to the well pads would be snow-plowed in the winter. All roads intended for year-round access would be surfaced with aggregate or cinder.

The well pads south of Paulina Creek would be for testing purposes only during exploration. Access to these pads would be via Road 21 or 22 to FS 2121. No new roads or other project facilities are proposed to cross Paulina Creek.

Project roads would be plowed as appropriate according to the Deschutes National Forest Road Rules for Commercial Users most current report to allow access to project activities.

Hazardous and Other Materials Used and Generated During Exploration. In concentrated form, a variety of the materials typically used during geothermal exploration are considered hazardous. As a consequence of these characteristics, these materials require special handling on site. Materials requiring special handling on site include lubricants, diesel fuels, oils, caustic soda, defoamer, lime, scale inhibitor, sodium bicarbonate, ammonium alcohol sulfate, corrosion inhibitors, polymers, and antifreeze. Other drilling chemicals anticipated for the project would be natural materials (e.g., cottonseed hulls, bentonite, ground nut shells, cellulose, salt and lignite dispersant). These are summarized in Table H-1 in Appendix H and are discussed in detail (e.g., hazardous ingredients, level of estimated hazard and incompatibility) in the transportation and material safety data sheets (T & MSDS) (CEE letter to U.S. Forest Service dated June 25, 1993). A copy of these T & MSDS sheets are available in the analysis file. A synopsis of these materials is given in Table 4.14-1 (in Section 4) and in Appendix H (Table H-1, Drilling Chemicals).

Anticipated waste streams from drilling operations would include cuttings containing used drilling mud, used engine/gear/hydraulic oil, municipal-type dry refuse, and empty drums. All hazardous materials would be trucked offsite for disposal to a certified hazardous waste disposal area (e.g., Arlington, Oregon, or other regional landfills deemed capable of accepting hazardous waste). Drilling muds, which under Federal regulations are generally considered nonhazardous, would be tested and if verified to be nonhazardous, would be disposed on site through filling and revegetation of the sump.

2.4.1.3. Development

Transition From Exploration to Development. The exploration phase is intended to provide data to allow a geothermal project to advance to the resource evaluation phase, based on a thorough geological evaluation of subsurface geological data. The exploration phase would bring the program to the point of testing the productivity and commercial development potential of the geothermal resource on the leases.

Once a sufficient number of exploration wells were drilled to define a resource adequate to produce 33 MW, then development activities could begin. Development activities would, in addition to supplying the initial 33 gross MW, help define the size and extent of the geothermal reservoir. Some estimates conclude that there is a potential for at least 130 MW for this area (Black 1993). This project could serve as an evaluation for possible future expansion. No future development would occur without additional environmental review under NEPA and approval.

The development phase of the project would include (1) the construction of the power plant, pipelines, and transmission lines, and (2) the development of production wells.

Power Plant and Related Facilities. This section describes the types of facilities that would be constructed at the power plant during the development phase. Operation of the facilities is discussed under Section 2.4.1.4.

- Plant Site. The power plant would be centrally located in the well field development area in order to minimize the cross-country piping. The power plant site would cover a total area of approximately 7.5 hectares (18.5 acres), which includes the equipment laydown area (for storage and operational activities), power plant pad, water storage ponds, cut and fill areas, and additional contingency for a fire break. The generally rectangular-shaped power plant site would be cleared of vegetation and graded to balance cut-and-fill requirements. Temporary warehouse and laydown areas would be located within the plant site. Any additional laydown areas needed during plant construction would be located adjacent to the plant area, within the 7.5-hectare (18.5-acre) area.

- Site Grading. Grading would be preceded by clearing and grubbing as necessary. Felled trees would be cut to commercial lengths and decked for salvage (as appropriate), sold, or hauled away for disposal. Slash would be burned. Stumpage charges would be paid to the U.S. Forest Service, as required. The plant pad would be designed to balance the cut and fill. Surface gradients on the plant pad normally would not be less than 1 percent or 0.003 meter per meter (0.01 foot per foot). Culvert and storm drains would be graded to produce minimum flow velocities in pipes of 0.6 meter (2 feet) per second for a mean annual rain.

  The site would be excavated with conventional excavation equipment. Cut-and-fill slopes would not exceed a 2:1 ratio (horizontal to vertical). Fill areas would be watered and compacted using appropriate construction techniques to meet appropriate geotechnical engineering standards (90 to 95 percent compaction).

  The plant site would be gently sloped and bermed to prevent water ponding and to direct runoff. On-site runoff would generally be directed to local topography, and internal plant and site drains would be directed to the water storage pond. The power plant site would be finished with gravel or asphalt. The plant site would be completely fenced with a 1.8-meter (6 foot) chain link fence to prevent unauthorized access. A minimum 15-meter (50-foot) fire break would be established and maintained around the plant site perimeter. The fire break was determined in coordination with the Oregon State Forestry Department, BLM, U.S. Forest Service, and the National Fire Protection Association (NFPA) standards. The NFPA standards suggest a 9-meter (30-foot) minimum fire break, with 15 meters (50 feet) the recommended width.

- Building Description. The main building would be a rigid, steel-frame, pre-engineered structure with steel panel walls and a steel roof. The building would consist of five sections, or bays, housing (1) the main equipment, (2) the H_2S abatement equipment, (3) the control room, switch gear and motor control center, (4) a shop and warehouse, and (5) the administration offices. Final design of the powerhouse and control building could, for safety purposes, require the H_2S abatement equipment to be housed in a separate building adjacent to the main power house. If required, this building would be a similar design and color as the main power house and control building. Figure 2.4-10 depicts the general layout of the equipment and building. Figure 2.4-11 presents an artist's conception of the proposed plant area. Figure 2.4-6 shows a photo of a state-of-the-art geothermal power plant.

- Power Plant Design. The selection of the optimum geothermal power plant system is a complex process that involves judgments about proven technology, resource characteristics, environmental constraints, and economic principles. Detailed design and optimization studies for the proposed project would not occur until specific reservoir data (such as temperature, pressure, and chemical composition) were available from the initial well testing. A conceptual design has been established, based on the resource data that are currently available for Newberry and through CEE's experience with the development of other geothermal power plants and well field facilities. Many of the design assumptions are based on the expectation that the geothermal resource characteristics would be similar to those found at the Medicine Lake geothermal resource (see Section 3.4, Geothermal Resources). The power plant is proposed as a modular "double-flash technology" plant with a condensing steam turbine and wet cooling tower. The plant would be supplied with steam and hot fluids through insulated pipelines from a network of wells located within 4.0 km (2.5 miles) of the plant.

This double-flash technology is considered a proven and commercially available geothermal technology. The plant systems and equipment would be designed and selected for a commercial life of 50 years.

Beyond the geothermal flash system equipment, the balance of plant equipment, in general, would be similar to that used in utility thermal power plants, such as:

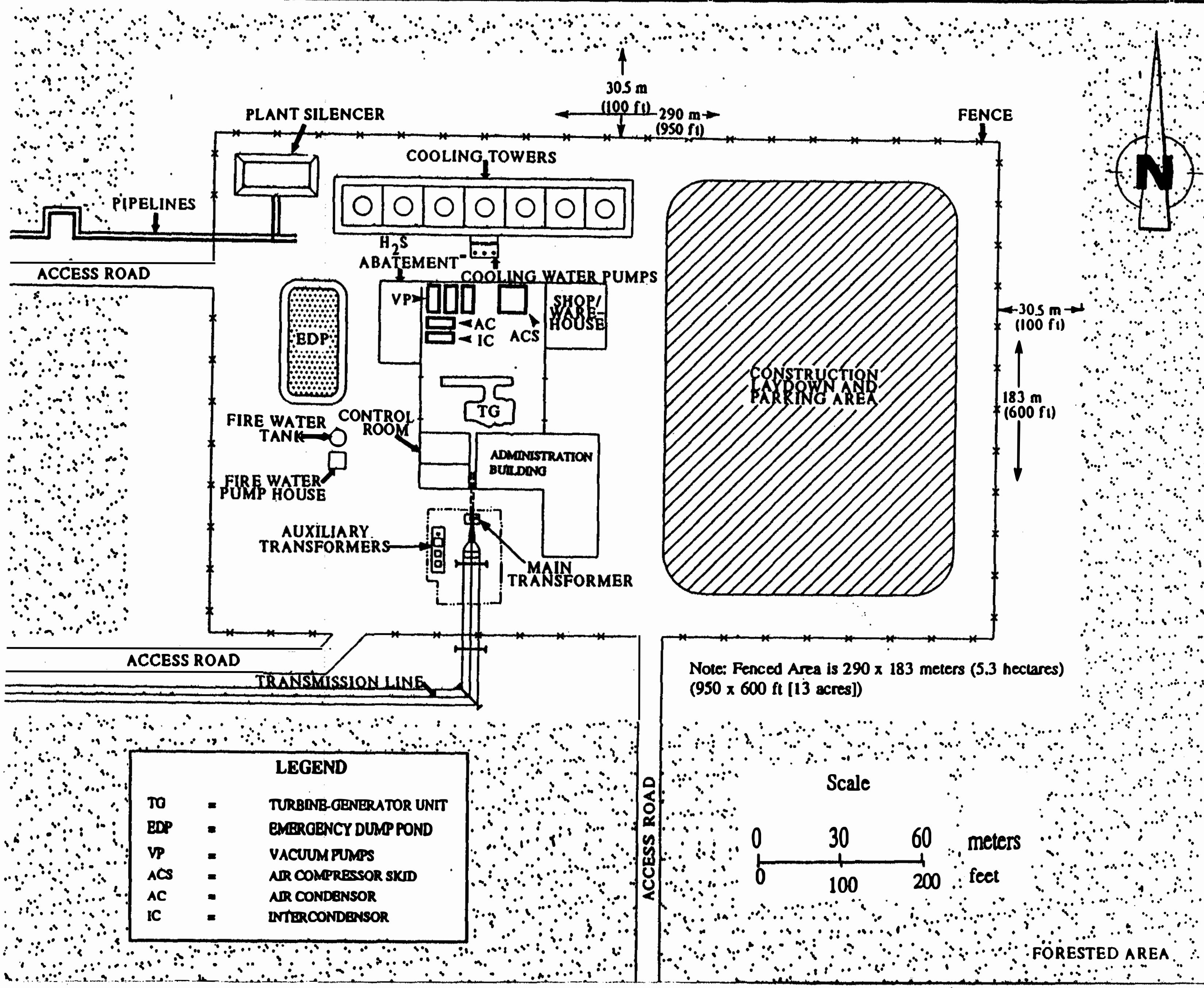
- Condensing steam turbines
- Generators
- Shell-and-tube condensers
- Cooling towers
- Pumps
- Noncondensable gas removal systems

- Steam Condensers and Cooling Tower. The condenser/cooling tower system (heat rejection system) would be designed to remove spent steam and noncondensable gas from the turbine exhaust while maintaining a vacuum on the unit. The system would consist primarily of a shell-and-tube surface condenser, a seven-cell evaporative cooling tower, and associated pumps, piping, and valves. Pumping spent steam directly to the injection wells is not feasible because of the inefficiencies involved.

NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

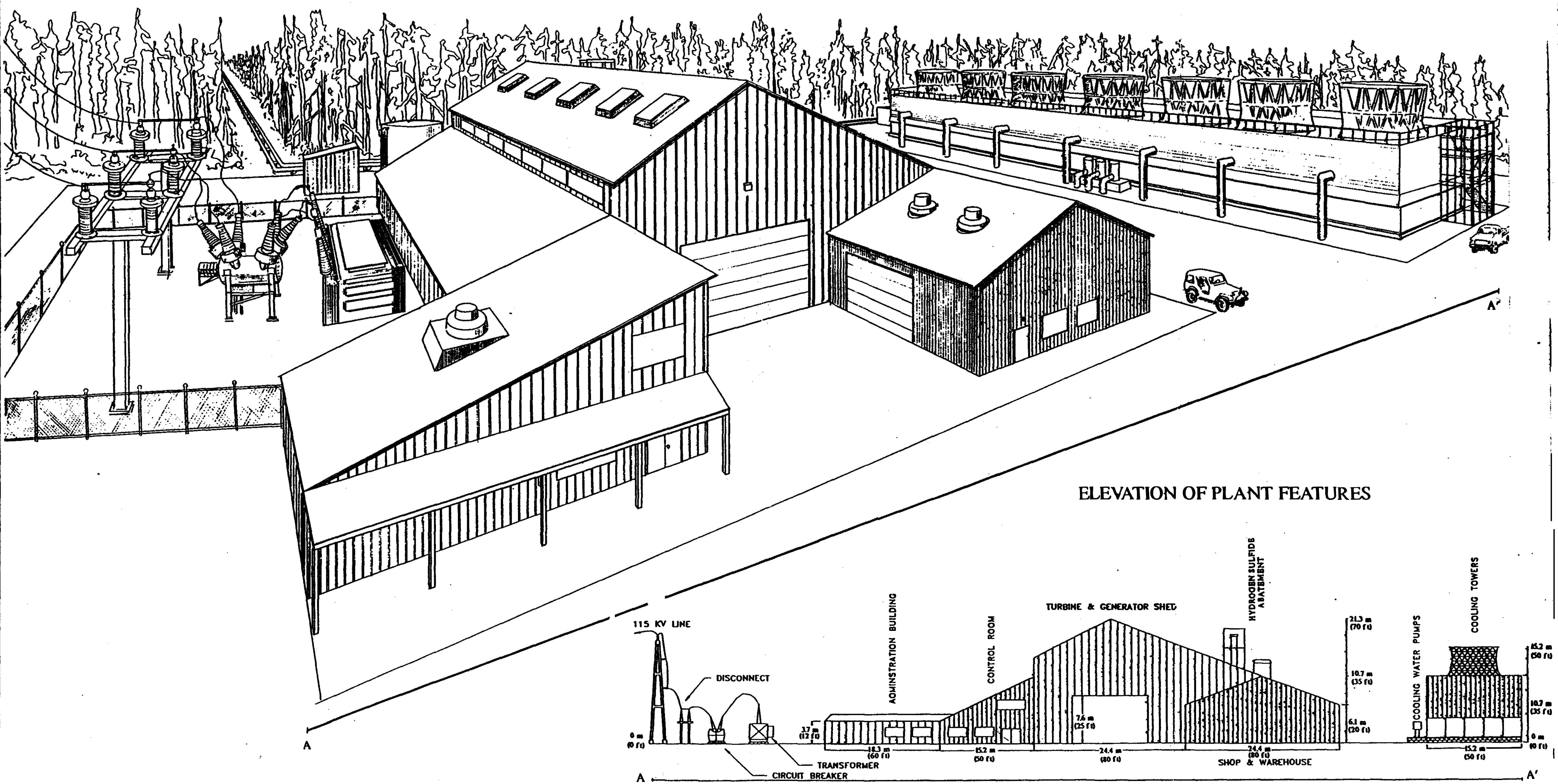
Power Plant Site Layout

Figure 2.4-10



Artist Conception of the Power Plant Site and Elevation of Plant Features

Figure 2.4-11



condensed steam (condensate) would be pumped into the cooling water return pipeline to provide additional cooling water. Excess cooling water would flow by gravity from the cooling tower basin to the plant water storage pond and then to the injection wells.

The cooling tower would be an evaporative (wet) tower and would be constructed of treated wood. The structure would be approximately 15.2 meters wide by 106.7 meters long and 15.2 meters high (50 feet wide by 350 feet long and 50 feet high). The tower is proposed to be slightly oversized (seven instead of four cells) in order to minimize the visibility of the plume. Before passing through the condenser again, the temperature of the cooling water must be lowered. This is accomplished by spraying the water through an upward-moving flow of air in a cooling tower. Some water is lost in this process, mainly through evaporation and partly because a small amount of water escapes as "drift" in the air stream. Depending upon ambient air temperature and humidity, the evaporated water may be visible as a plume. The higher the humidity and lower the temperature, the more visible the plume.

During most of the year, there would be a positive water balance (i.e., the plant would produce more water than required for cooling) due to geothermal condensate used as the primary make-up water system.[1] The cooling tower is expected to evaporate approximately 1.9 million cubic meters (1,580 acre-feet) of water per year. Secondary make-up water would be provided from shallow water wells located in the area. After use in the power plant and cooling towers, this water would be injected into the geothermal reservoir to maintain reservoir pressures and to dispose of excess geothermal fluids. The longitudinal axis of the tower would be oriented in an east-west direction to take advantage of the prevailing westerly winds to minimize recirculation. The reason for placing the longitudinal axis of the cooling towers parallel to the predominant wind flow is to minimize the amount of warmed (by hot water in the cooling tower) air re-entering the bottom of the cooling tower. A certain amount of warm air will be trapped in a downflow on the leeward side of the tower and will recirculate through the tower, reducing its efficiency. When the longitudinal axis of the tower is parallel to the wind, most of the air enters at the sides of the tower, and recirculation is largely limited to the leeward cell. When the cooling tower operates efficiently, the steam plume is minimized.

- Plant Water Storage and Sump Pond. A 1.4 million-liter (360,000-gallon) water storage and sump pond would be located at the power plant site adjacent to the cooling tower to collect flows from the steam muffler, cooling tower overflow, rain and snowmelt runoff, equipment drains, and various spill containment areas. The pond would be approximately 42.7 meters long by 18.3 meters wide and 2.4 meters deep (140 feet long by 60 feet wide and 8 feet deep). The capacity of the pond (454,000 liters [120,000 gallons]) would be sufficient to hold more than half of the volume of the cooling tower basin while maintaining a 0.6-meter (2-foot) freeboard. The pond embankment would be constructed using 2:1 horizontal-to-vertical slopes. The pond would be lined with a minimum of 15.2 cm (6 inches) of a compacted clay and a high-density polyethylene liner, or other suitable liner. Fiberglass fences would be constructed around the pond to keep wildlife out of the fluids. The pond would provide a collection and temporary storage area for the various plant drainage systems. The pond pumps would transfer these fluids to the injection wells for disposal.

The power plant water storage pond will contain mainly excess condensate and cooling tower overflow. This fluid is essentially condensed steam (distilled water)

[1]Make-up water is the water that must be supplied to the condenser to replace water lost in the cooling tower. It will normally be supplied by condensed steam from the turbine.

containing small amounts of dissolved gases, and is low in dissolved solids. Excess condensate and cooling tower blowdown can also be sent directly to the injection wells. Water stored in this pond will be used for fire control protection and as make-up water for the cooling tower during high evaporation periods (which also occur during fire season). The fluids in the power plant water storage pond are not expected to have high amounts of dissolved solids, and will therefore have only minor sedimentation. If the ponds are cleaned to remove sediment build-up, these sediments will be tested to determine if they are hazardous. It is not known at this time how often this will be, if ever. If the contents are found to be hazardous, then the material will be disposed of at an approved licensed disposal facility.

Systems with drainage to the water storage pond would include the following:

- Stormwater Runoff. Rain and snowmelt runoff from the equipment areas on the plant pad would flow to storm drains and through an oil/water separator prior to draining to the water storage pond.

- Miscellaneous Equipment Drainage. Various and periodic drainage from equipment would be sent to the water storage pond either directly (such as the steam muffler drainage, steam trap drainage, etc.) or indirectly through the storm drainage system (such as maintenance water, drainage during condenser cleaning operations, etc.).

- Spill Containment Areas. Clean water removed from containment areas would be directed to the water storage pond. The plant water storage pond would have an emergency outflow through an overflow pipe which allows a controlled flow rate to natural drainage. Sediment would remain in the bottom of the pond and would be cleaned out and disposed periodically on an as-needed basis.

- Noncondensable Gas Removal System. Noncondensable gases (such as carbon dioxide, H_2S, nitrogen, and methane) are expected to be present in the steam. The largest constituent in the gas stream is expected to be carbon dioxide (CO_2), generally comprising 95 to 98 percent of the total gas, with smaller amounts of other gases such as H_2S, nitrogen (N_2), and methane (CH_4). H_2S is the primary concern because at high concentrations it can have adverse health effects. The majority of these gases are separated into the steam phase during the flashing and steam separation operations. These gases would be separated from the produced geothermal fluids in the steam operations and would pass with the water vapor through the turbine and be removed from the condenser. The gases would then be routed to the H_2S control system, which would be a liquid redox system (see the discussion under Section 2.4.1.4, Utilization).

- Plant Site Access Roads. The plant would need to be accessible on a year-round basis. The main year-round access road to the power plant would be surfaced with aggregate or cinder. Forest Service Road 9735 would be the main access road from Highway 97 (see Figure 2.4-2). Spur Road 9735-600 would be rebuilt and surfaced from Road 9735 to the power plant. The main access road and the local spur roads to production well pads would be plowed in the winter.

Well Field Development. Although production wells would have additional instrumentation and would be connected to pipelines, they would be essentially the same as exploration wells. Approximately eight to ten production wells and three to five injection wells may be required to supply steam to the 33 MW power plant. Additional replacement wells would be required to support the power plant for the proposed 50-year life of the project. These replacement wells would be drilled on the proposed 14 pads. Figure 2.4-12 presents the layout of a multiple well production pad, and Figure 2.4-13 shows the artist's conception of a well pad. Production wells are discussed under Section 2.4.1.4, Utilization.

Injection Wells. Injection wells are likely to be non-commercial exploration wells with adequate permeability to accept fluids in a location that would not interfere with production. These wells would be used to dispose of excess brine (that is too low in temperature to flash to low-pressure steam), excess steam condensate, excess cooling tower water, and some noncondensable gas for control of scale formation in the wellbore. These injection wells would be similar in size to exploration and production wells.

Pipelines. Each commercial production well would be connected to one of several high-pressure separators and steam supply pipelines that transport steam to the turbine. Figures 2.4-14 and 2.4-15 depict a typical pipe corridor. Production (steam-supply) pipelines would be 91 cm (36 inches) in diameter, including insulation to maintain steam temperatures.

Injection lines would carry excess brine, condensate, and cooling tower blowdown to the injection wells. Injection lines would be 30 to 61 cm (12 to 24 inches) in diameter and would be located on the same pipe supports as the steam supply pipelines. Injection lines would be smaller in diameter as they may not require insulation. The remaining liquid that would flow out of the high and low pressure separators would be diverted to injection pipelines, and then to the injection wells. Pipeline corridors would also include electrical conduit pipelines (10 cm [4 inches] in diameter) for well head instrumentation.

Pipeline thermal expansion would be accommodated by a series of sliding pipe supports, expansion loops, and anchor pipe supports. The expansion loops would be primarily horizontal (see Figure 2.4-14, pipeline corridor), although vertical loops would be used in some locations, such as at the power plant, road crossings, wildlife, or recreation use areas.

The steam gathering and injection pipeline corridors would be routed through existing cleared areas and along existing logging roads, to the extent practical. Pipelines and support structures would be painted to blend with surrounding colors. Permanent access roads approximately 3.7 meters (12 feet) wide along pipeline routes are generally required for maintenance purposes. The pipeline construction corridor would be up to 36.7 meters (120 feet) wide but would more typically be 27 meters (90 feet) wide or less. After construction, the corridor would be allowed to revegetate, where practical, with approximately 25 percent of the pipeline corridor dedicated to pipeline piers, footings, and access roads.

Transmission Lines. The project would require building a new transmission line in order to deliver power to the existing BPA switchyard near LaPine, Oregon. CEE proposes to construct a 115-kV line with H-frame, wood-pole construction (Figures 2.4-15, 2.4-16 and 2.4-17). Figure 2.4-17 shows a typical cross section of the western portion of the transmission line for this alternative with an H-Frame-type structure. The line would be owned by CEE or Midstate Electric. The transmission line would be designed to allow future expansion to about 100 MW without rebuilding the line.

The proposed route proceeds westward from the power plant site paralleling Road 9735 (on the north side of the road) to the BPA transmission line right-of-way (Figure 2.4-2). The proposed route would cross under the BPA 230-kV power line and proceed west across U.S. Highway 97 near the junction with the LaPine State Park Road, then parallel that road on the south side to Midstate Electric's existing 115-kV transmission line. CEE believes the proposed route would be the most direct and cost-effective route of all the alternatives considered (CEE, 1992b). The route would parallel Road 9735, which would be the main access route for the project and would allow easy access for winter transmission-line maintenance.

The proposed transmission line would require a new switchyard to be built at the interconnection point with the Midstate Electric's 115-kV line in Section 7, T.21 S., R.11 E. on BLM lands. This switchyard would require a secure, fenced-in area of approximately 15.2 meters by 15.2 meters (50 feet by 50 feet) and would be located on BLM lands. The switchyard would consist of:

- Gas circuit breaker
- Motor-operated disconnect switches
- Protective relays
- Revenue meters

The revenue meters would be housed in a prefabricated enclosure. This transmission line would be tied into the local Midstate Electric Cooperative line. All equipment would be compatible with Midstate's existing system.

Transmission line construction would begin with preparation of the right-of-way, which includes clearing for permanent and temporary access roads, staging areas, and the laydown areas at each pole site. CEE proposes that a 30.5-meter (100-foot) wide right-of-way be cleared for this line. Generally, a 5.5-meter (18-foot) wide permanent access road would be needed for the length of the transmission line to provide access for maintenance. Forest Service Road 9735 would serve as the access road for much of the line length. New access road construction would be necessary near the plant site. Existing logging roads would be used to the extent practical for this new section and for temporary access roads during construction.

An overhead grounding wire would be provided for lightning protection. Guy wires would be installed and tightened before conductor or overhead ground wires were strung.

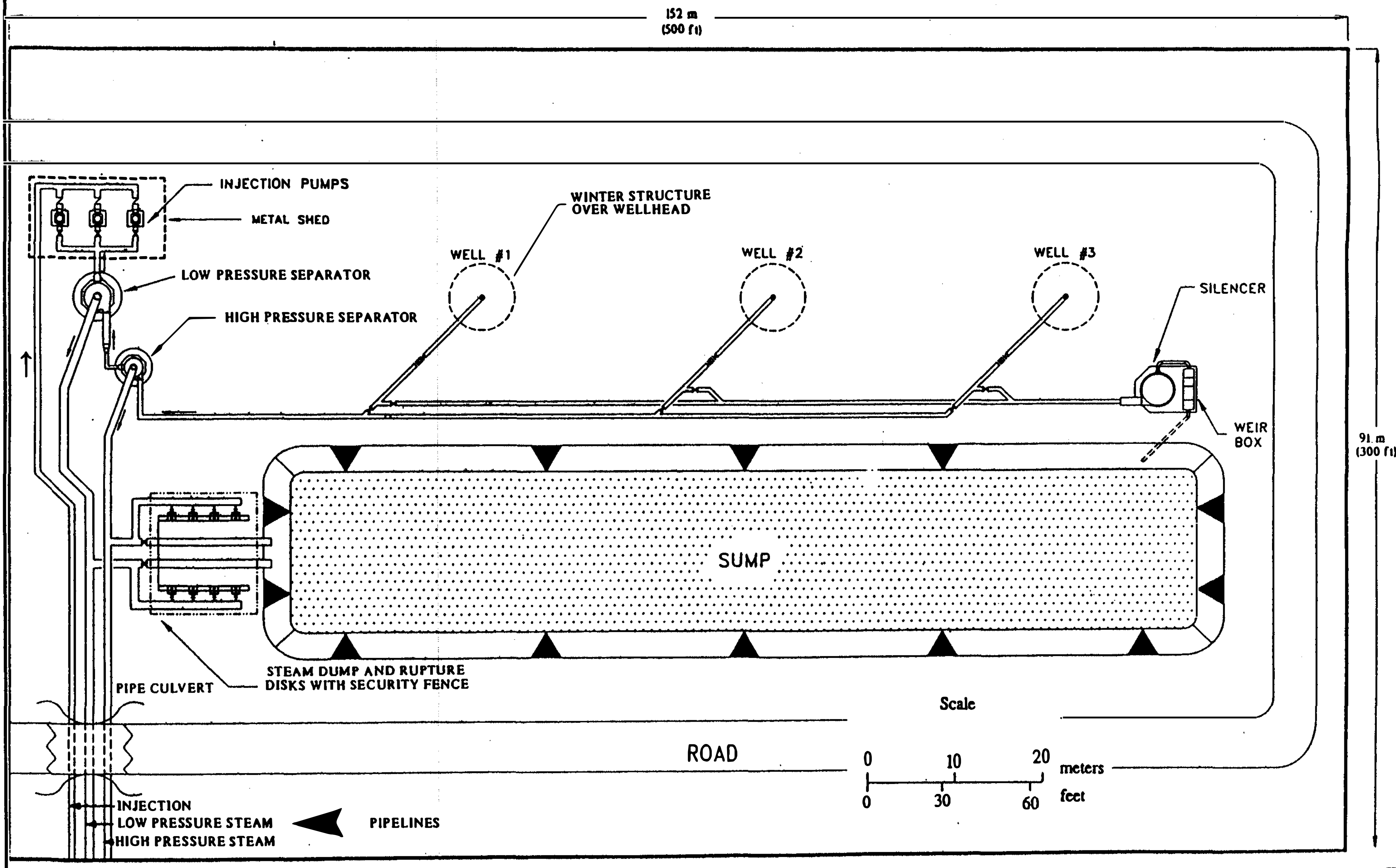
2.4.1.4. Utilization

Utilization consists of three main activities: steam production and injection, power plant operation, and maintenance. Activities described in Utilization are those that involve the ongoing operation of the plant. All operations would be conducted, and wells would be plugged and abandoned, in accordance with the Federal GRO Orders and stipulations of the Deschutes National Forest and BLM.

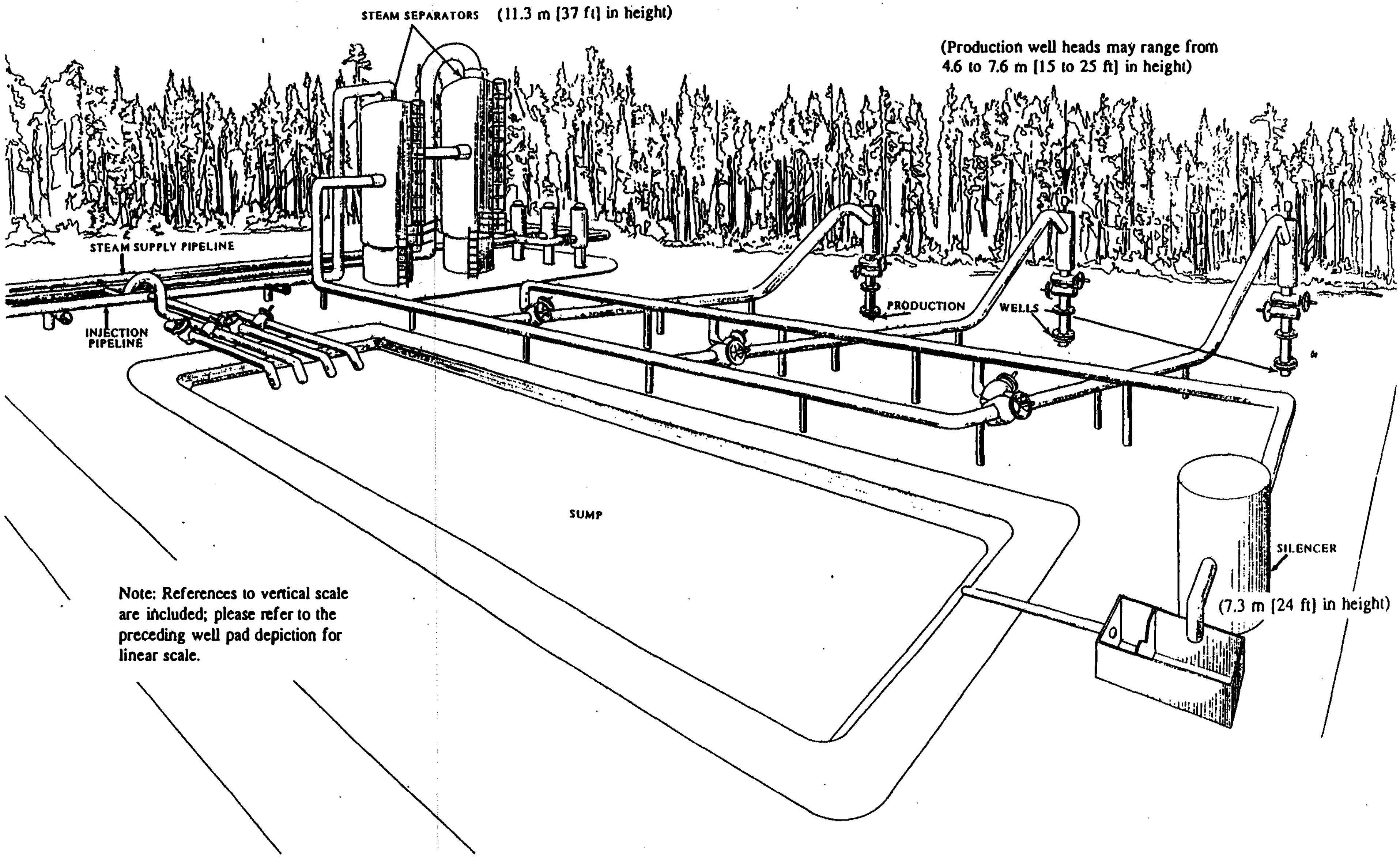
Production Wells. Examples of production wells are shown in Figures 2.4-13 and 2.4-18. Figure 2.4-19 depicts the typical wellhead configuration for a production well. The production wells would flow naturally to the surface. Chemical additives would likely be used to reduce the potential for build-up of scale-like mineral precipitates in the well. These additives would be injected into the production wells via a tube on an as-needed basis. The appropriate types and amounts of additives would be determined after testing and might not be needed until after several years of operation. Downhole chemical inhibitors would be used only after prior approval by BLM.

Separators. Each production well is expected to produce steam and hot water. Steam would be separated from the hot water in several high-pressure (HP) separators which would be located in the well field (see Figures 2.4-12 and 2.4-13). High-pressure steam separators would be located on the well pads and interconnected to several wells. Steam from the HP separators would be interconnected to a common steam supply pipeline to the power plant. Liquid from the HP separators would be piped to a low-pressure steam separator on the well pads where the remaining steam would be flashed, separated from the liquid, and transmitted to the power plant via the low-pressure steam pipelines. Liquid from the low-pressure separators would be sent to the injection wells.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Multiple-Well Production (Steam Supply) Well Pad	Figure 2.4-12



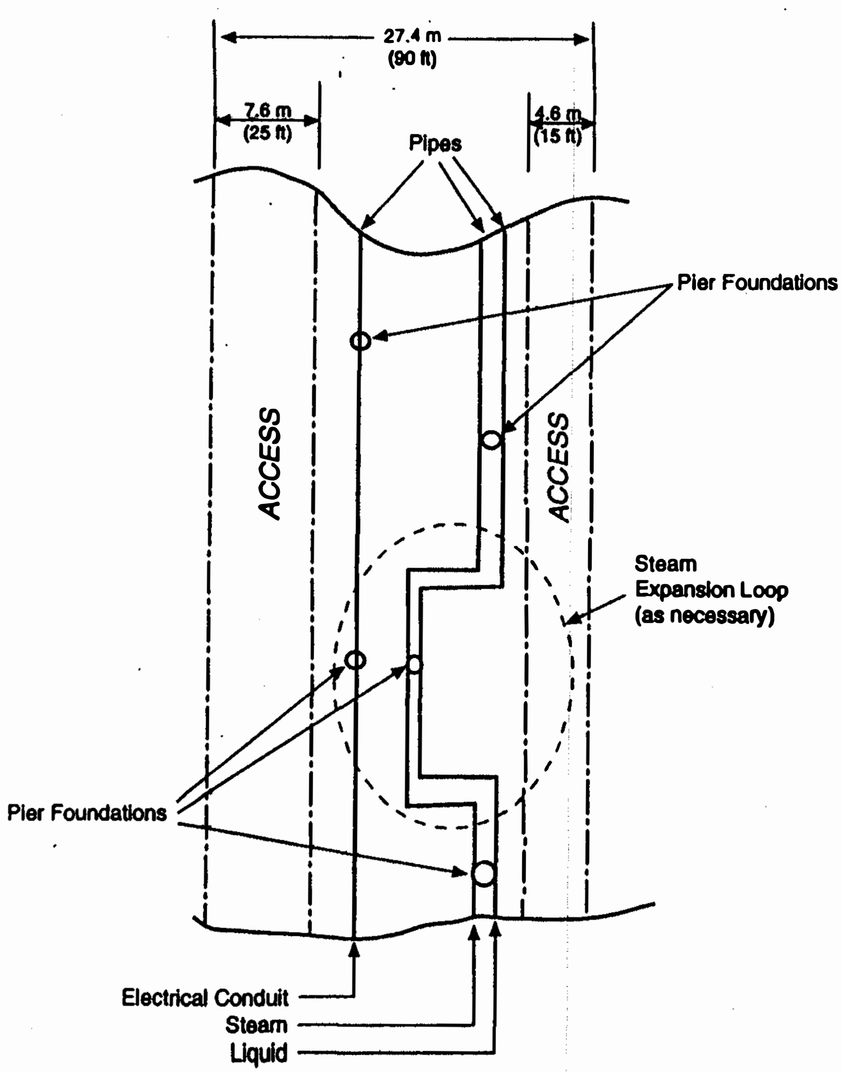
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Artist Conception of a Multiple-Well Production (Steam Supply) Well Pad	Figure 2.4-13



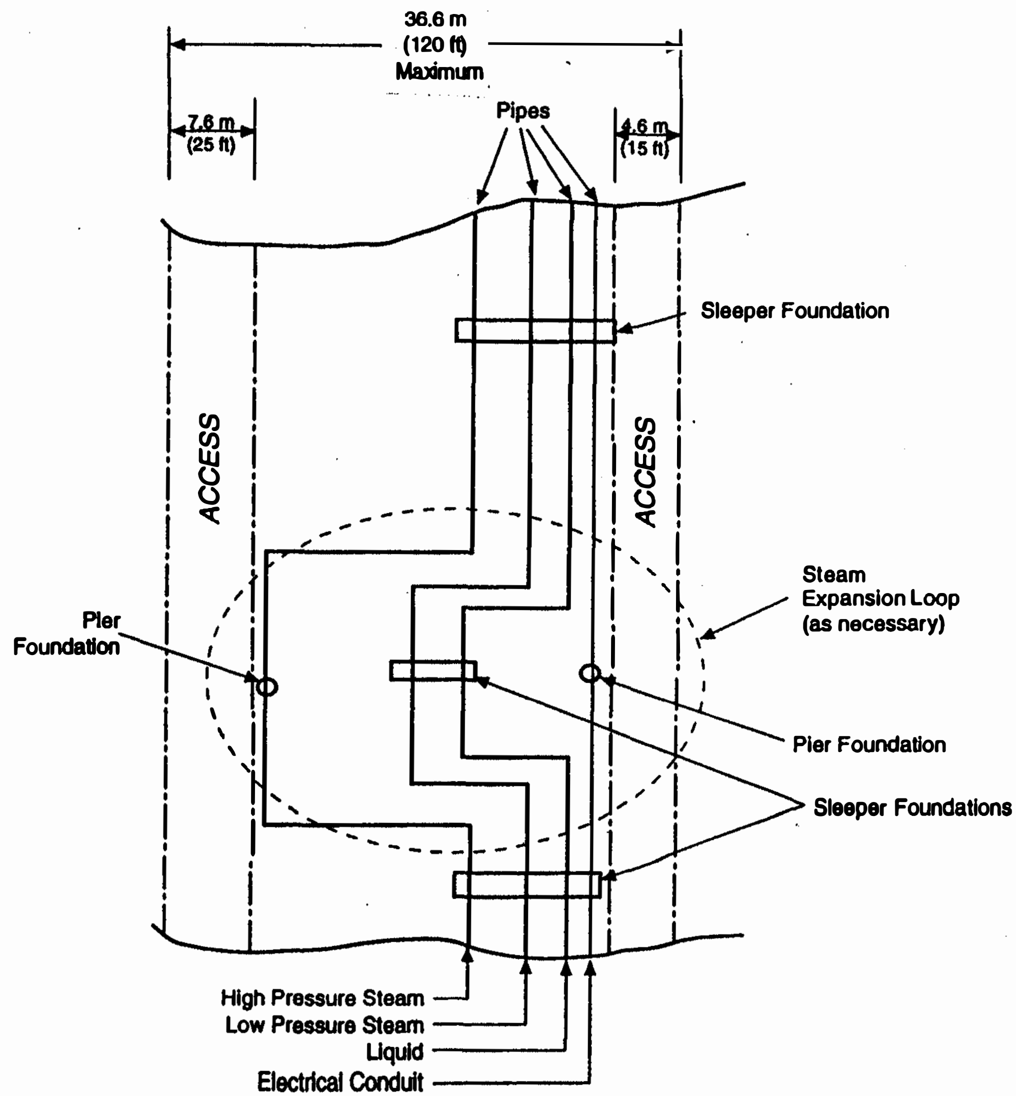
Note: References to vertical scale are included; please refer to the preceding well pad depiction for linear scale.

Notes
1. Pipes are represented as single lines. Multiple pipes may exist in a typical pipeline corridor.
2. 36.6 m (120 ft) is width required for multiple expansion loops. A more typical width would be 27.4 m (90 ft) or less.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Pipeline Corridor Width	Figure 2.4-14



Typical Configuration of a Single Steam Line Pipe Corridor

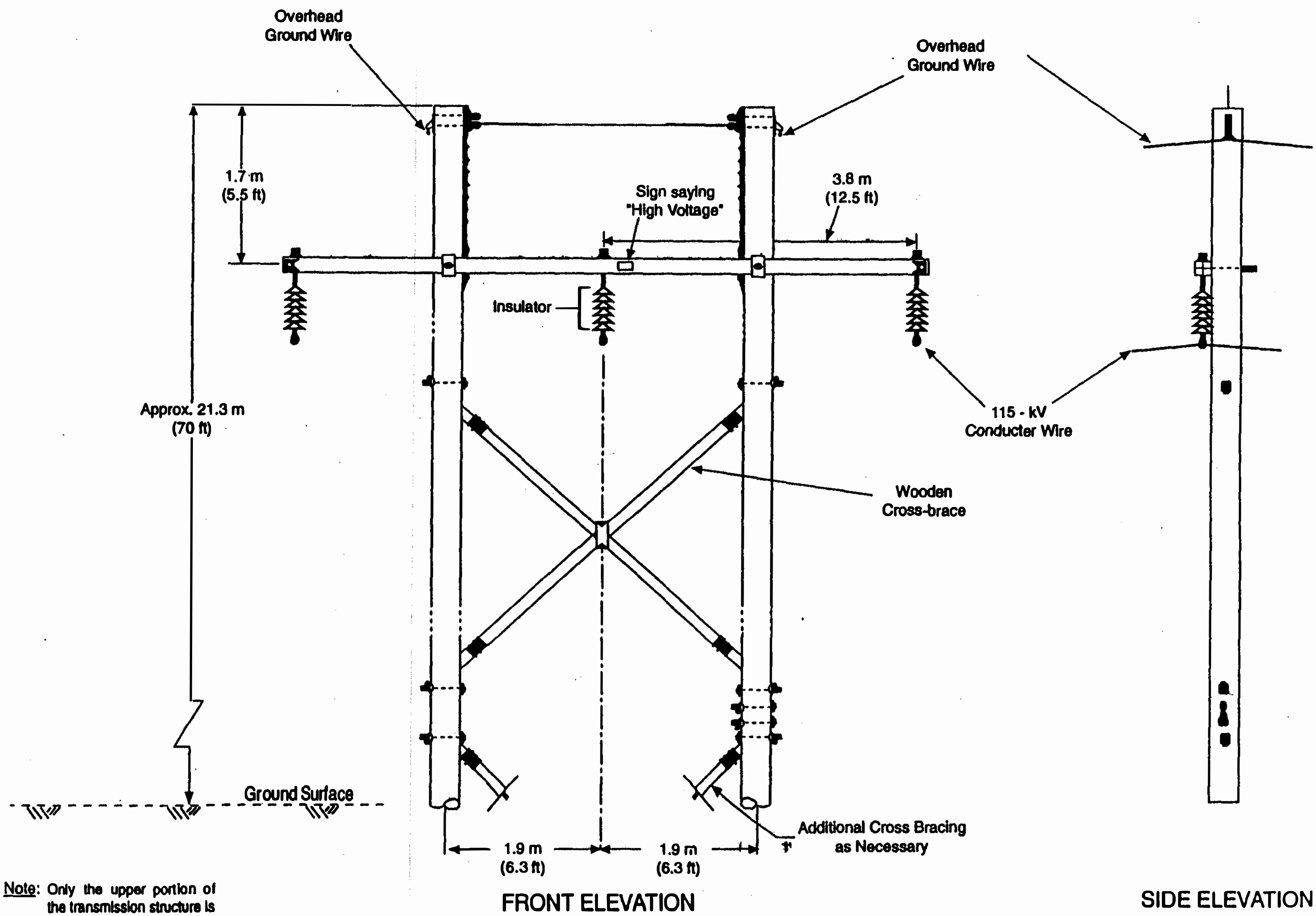


Typical Configuration of a Multiple Steam Line Pipe Corridor

A pipe corridor at The Geysers, California

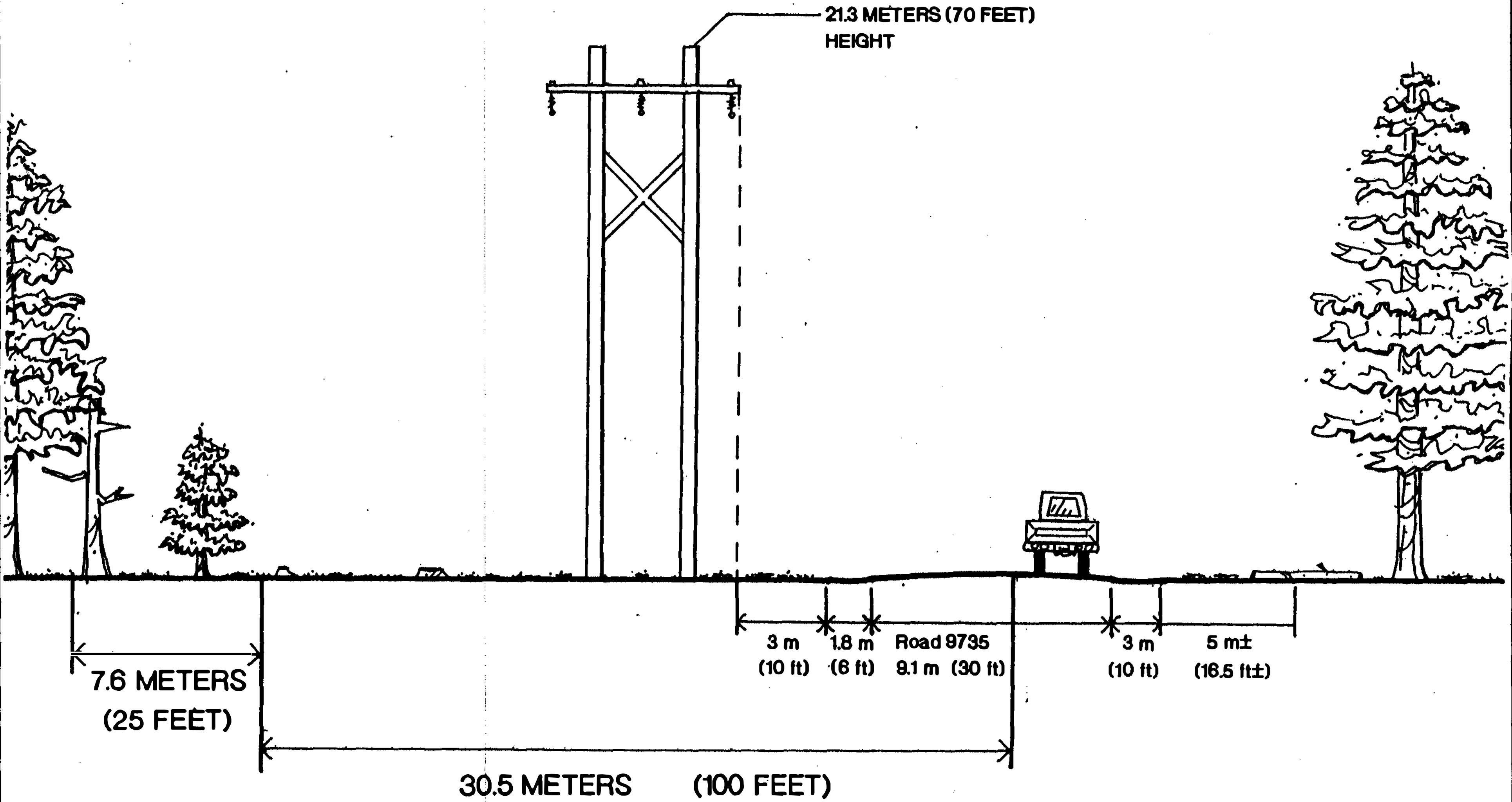
Example of the H-frame wood-pole construction proposed in Alternative A

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical H-Frame Transmission Line Structure	Figure 2.4-16



Note: Only the upper portion of the transmission structure is shown.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Cross-Section of Western Portion of Transmission Line -- Alternative A	Figure 2.4-17



SCALE:
1 cm = 24 m
1 inch = 200 ft

Power Plant. The power plant facilities would include a steam turbine that would produce 33-MW gross output by driving an air-cooled generator. The generator would be provided with a solid-state automatic voltage regulator, a main generator circuit breaker, current and voltage transformers, and protective relaying. The generator would produce electrical power at 13.8 kV, which would be stepped up by the main transformer to 115 kV for efficient transmission.

Electrical power for the plant auxiliary equipment would be supplied through three auxiliary step-down transformers. An auxiliary transformer would provide 4.16-kV power for major motors, such as those for the main circulating water pumps. The next step-down transformer would provide 480-V power for the majority of the plant auxiliary equipment, such as the cooling tower fans, condensate pumps, and vacuum pumps. The third would provide 120-V power for utility and lighting for the plant and buildings. A conceptual illustration of the power production process for the proposed project is presented in Figure 2.4-20.

Winter Provisions. The project area is anticipated to have an average snow accumulation of 12.7 to 15.2 cm (5 to 6 inches) per month during the winter months of November through March. Cumulative snow depths up to 1.2 meters [4 feet] have been measured at the project site. As such, special winter provisions would be needed for the fluid gathering and injection systems. It is proposed that removable enclosures be provided to protect certain equipment and to provide clear access to the equipment areas. Heat tracing (heated wires to prevent freezing) would also be provided on all piping that has the potential to freeze (such as sight-level gages, chemical-injection piping and tubing, etc.).

Well heads would be insulated (see example in Figure 2.4-18) for heat retention and may be covered with a prefabricated metal building similar in shape as a small grain silo. Prefabricated metal buildings, which can easily be removed in the summer months, would be provided to cover well pad equipment such as well heads, injection pumps and chemical injection skid areas.

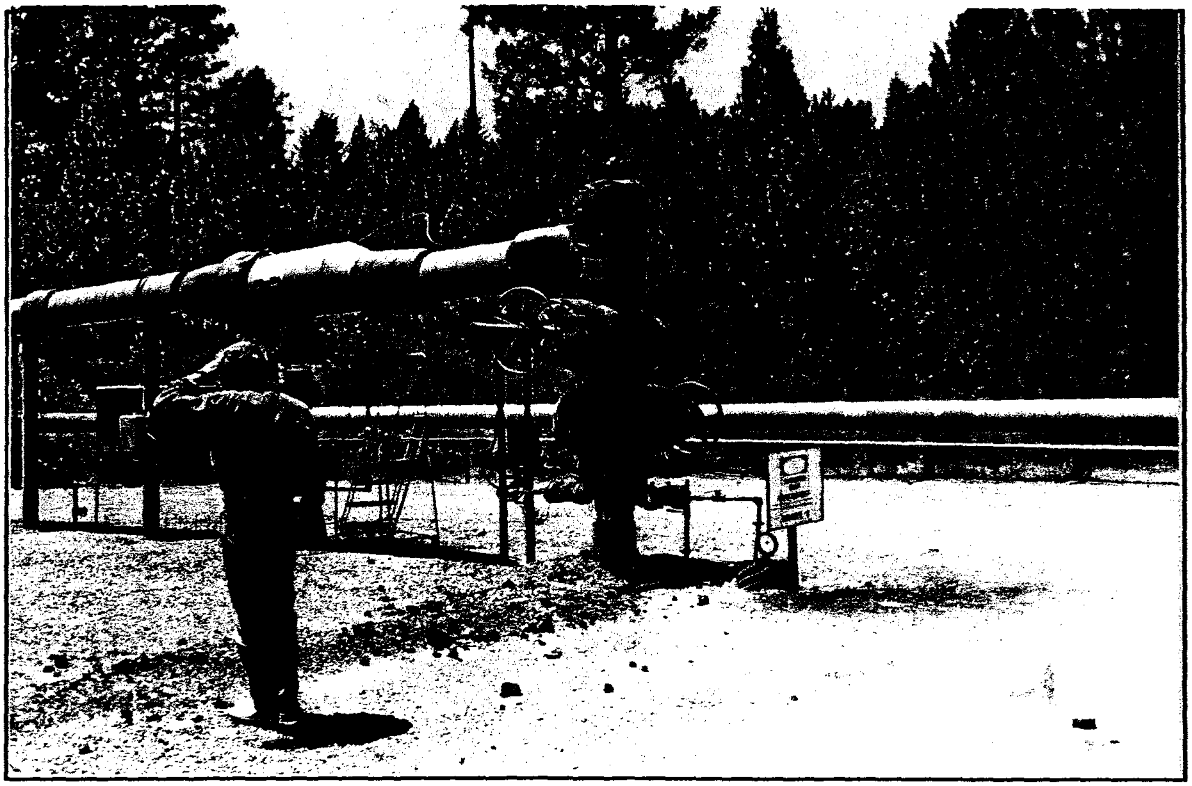
Winter access into the project area would be improved by snow-plowing and would be negotiated with the U.S. Forest Service.

Waste Disposal.

- Waste Disposal/Pressure Maintenance Facilities. The Plan of Disposal (CEE 1992b) addresses waste disposal methods that would be used for the power plant and the well field, including water-handling systems, solid waste, noncondensable gases, and excess geothermal fluids. It is expected that excess geothermal fluids would be injected back into the geothermal reservoir, in locations away from production zones in order to maintain reservoir pressures. This injected fluid would consist of excess brine and cooling tower blowdown. The composition of the fluid cannot be determined exactly until samples of the resource fluids are available for analysis. However, it is expected that the injected fluids would be similar in chemical composition to produced fluids (i.e., fluid drawn from the geothermal reservoir) but would be more concentrated in total dissolved solids. This is because a portion of water from the produced fluid would be lost to steam, thus concentrating the brine left over after electrical production and evaporation in the cooling tower. The anticipated chemical composition of the produced fluid is shown in Table 2.4-5, where it is compared with the chemistry of campground supply wells in the vicinity, of Paulina Creek, and of sea water. A further comparison is made in Section 3.4, Geothermal Resources, with the Paulina and East Lake Hot Springs. The predicted chemical composition of Newberry geothermal fluids is based on geothermal research at Newberry, experience at other geothermal fields, and the fluid composition of the Medicine Lake, California, geothermal reservoir (which is believed to be most similar to Newberry and is located in the southern Cascade Range). Composition of the injected fluid would be reviewed by BLM and ODEQ. Any necessary permits required for injecting the fluid would be obtained.

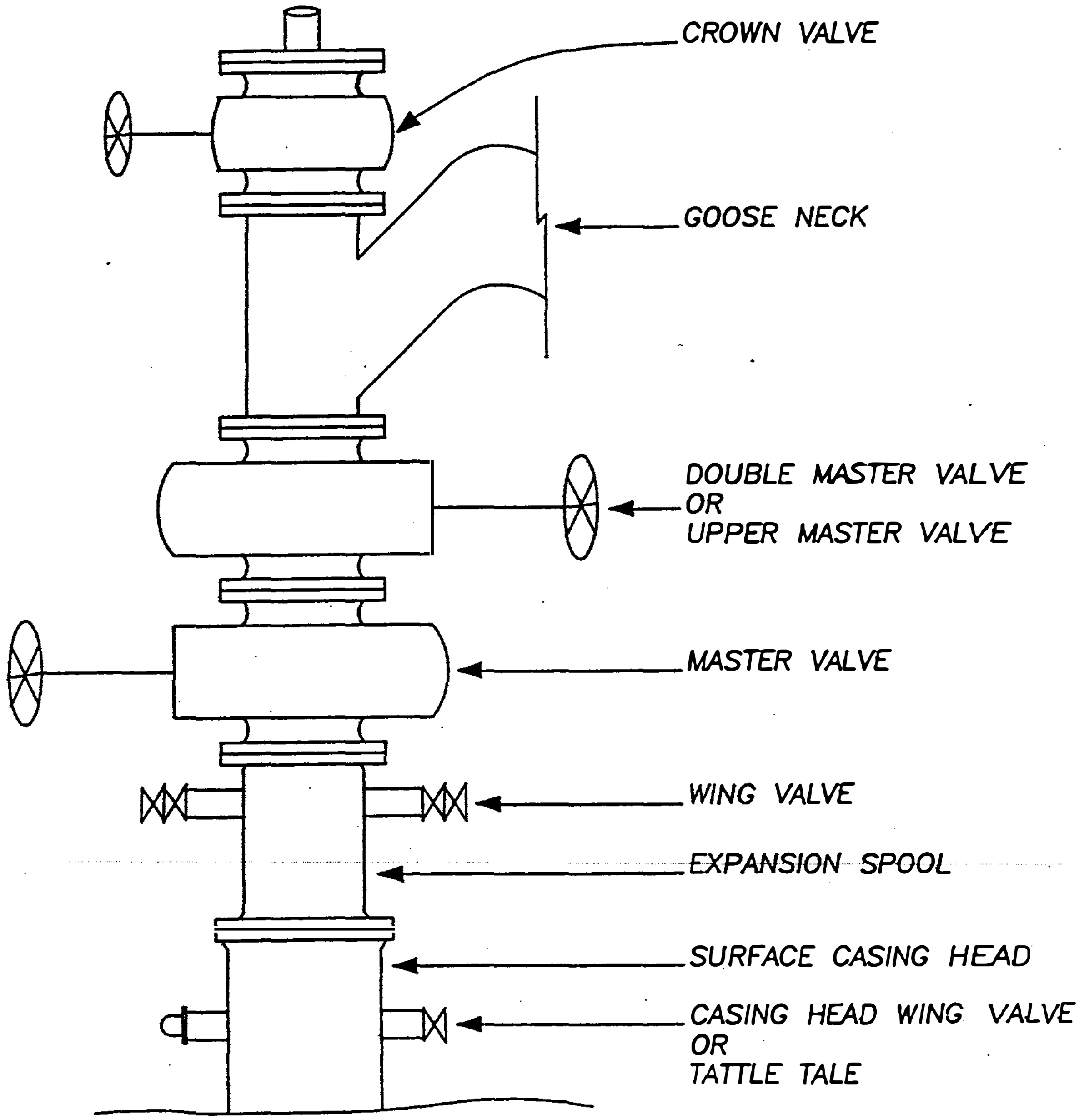
Production Wellhead Photo

Figure 2.4-18

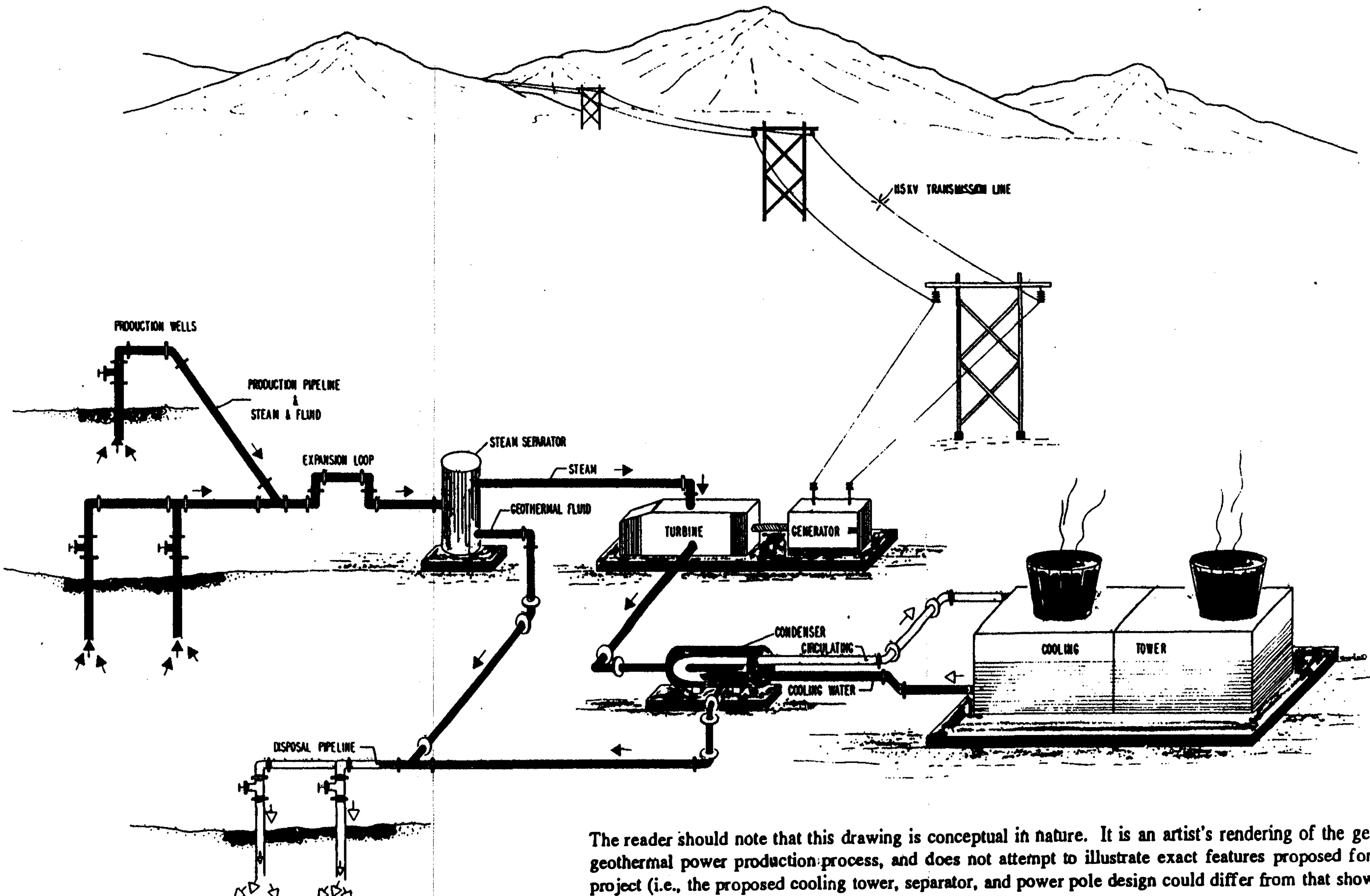


Example of a production wellhead

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Wellhead Configuration of a Production Well	Figure 2.4-19



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Conceptual Illustration of the Geothermal Power Production Process	Figure 2.4-20



The reader should note that this drawing is conceptual in nature. It is an artist's rendering of the general geothermal power production process, and does not attempt to illustrate exact features proposed for this project (i.e., the proposed cooling tower, separator, and power pole design could differ from that shown in this diagram).

Table 2.4-5 Fluid Chemistry Comparison

Component or Parameter	Units	Newberry Geothermal Project Brine[1]	Newberry Geothermal Project Condensate[1]	Paulina Guard Station Well[2]	Hot Springs Campground Well[2]	Paulina Creek Near Lake[2]	Sea Water[3]
pH		6.5 - 8.5	4.0 - 5.5	6.9	6.5	8.4	8.1
Ca	mg/l (ppm)	15 - 45	0.1 - 0.2	19	9.9	28	400
Mg	mg/l (ppm)	<2.0	0.1 - 1.0	2.7	4.2	39	1350
Na	mg/l (ppm)	900 - 2300	0.5- 7.0	6.5	9.1	47	10,500
K	mg/l (ppm)	140 - 600	0.3 - 2.5	1.6	2.5	5.6	380
Cl	mg/l (ppm)	1600 - 4100	1.0 - 1.5	7.4	12	4.6	19,000
F	mg/l (ppm)	1.5 - 8.0	<1.0	0.7	0.1	0.6	1.3
SiO_2	mg/l (ppm)	600 - 850	1.5 - 5.0	43	44	41	NA
Total Dissolved Solids	mg/l (ppm)	3000-7600	10 - 50	87	124	376	NA
As	mg/l (ppm)	6.0 - 9.5	<0.3	0.003	<0.001	0.015	0.003
Be	mg/l (ppm)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0000006
B	mg/l (ppm)	10 - 100	0.2 - 1.7	0.020	0.10	0.880	4.6
Pb	mg/l (ppm)	<0.1	<0.1	<0.010	<0.010	<0.010	0.00003
Hg	mg/l (ppm)	<0.02	<0.011	<0.0001	<0.0001	<0.0001	0.00003
NH_4	mg/l (ppm)	<1.0	<2.0	0.020	0.020	0.020	NA

[1]Assumed range for Newberry Geothermal Pilot Project
[2]Source: U.S. Geological Survey 1994.
[3]Average composition of surface waters (Goldberg 1963)
NA - Not Analyzed

- Geothermal Fluid and Waste Water Disposal Wells. All spent geothermal fluid remaining after flash steam separation and cooling tower blowdown would be disposed through injection wells back to the geothermal reservoir. Exploration and production test wells with poor production characteristics would be considered candidates for injection wells. Waste water from cooling tower overflow and plant drains would also be routed to the injection wells. A detailed Plan of Injection would be submitted prior to construction of facilities after well field drilling and testing had been partially completed. The plan would consider the composition of the various wastewater streams and options for separating the streams should that be necessary to preclude the degradation of natural water quality as defined by OAR 340-40-010. Injection of residual fluids from plant operations would be used as a reservoir pressure maintenance tool, and injection wells could be located along the perimeter of the well field as well as in the production areas. The injection wells would be drilled to include injection capacity in excess of 100 percent of plant operating requirements.

- Injection System. The liquid remaining after steam is separated (i.e., brine) would flow out the bottom of the low-pressure separator to the suction side of the brine injection pumps. Three vertical turbine-type brine injection pumps (two running and one on stand-by) are proposed to pump the spent brine through 30.5- to 61-cm (12- to 24-inch) diameter piping to the injection wells for disposal. Cooling tower blowdown (i.e., the fluid in the cooling tower that "washes out the basin") and other plant effluents would also be injected into the reservoir for disposal. Fluids would be injected at low pressure (less than 200 psi). These fluids would be included in the Plan of Injection which would consider their composition and origin to preclude the degradation of natural water quality as defined by OAR 340-40-010. Injection of these fluids would help maintain reservoir pressure and replenish the reservoir, thereby prolonging the commercial life of the geothermal resource. Injecting additional fluid to mine the heat more rapidly would be counter to the "sustained use" goal of the project.

Cooling System. The heat rejection at the outflow end of the turbine would create a vacuum, which enhances turbine efficiency. The cooling towers would be used to reduce the temperature of condensed steam in order to provide cooling water for the condenser. The cooling system would consist primarily of a side-mounted surface condenser, an evaporative cooling tower, three cooling water pumps, two condensate pumps, two component cooling water pumps, and associated piping and valves. The condensed steam would be routed through the cooling tower, where the condensate would be subject to evaporative air cooling. The condensate would be pumped from the cooling tower basin, through the condenser, and back to the top of the cooling tower by three cooling water pumps (two pumps would operate continuously while the third pump is on hot stand-by). Excess cooling water would flow by gravity from the cooling tower basin to the plant water storage pond. Biocides used in the cooling tower to prevent algae buildup would occasionally be allowed into the water storage pond for the same purpose. CEE will use biocides that break down rapidly in sunlight, that require high concentrations and long exposures to be toxic to fish and wildlife, and that have been approved by the Oregon Department of Environmental Quality. Cooling tower treatment generally occurs once per month in summer and once every three months in winter. During the winter and during periods of cooling tower treatment, cooling tower overflow is sent directly to the injection system.

Noncondensable Gas Removal System. A variety of naturally occurring gases would be entrained in the geothermal fluids produced from the production wells. The majority of these gases would enter the steam phase in the separators. All of the steam (low and high pressure) and gas would pass through the turbine to the condenser, where the steam would be condensed back into water that would flow to the cooling towers. The remaining gases that did not condense back into water (i.e., noncondensable gases) would collect in the condenser and be removed by a series of steam-driven ejectors and vacuum pumps. The largest constituent in the gas stream is expected to be carbon dioxide (CO_2), generally comprising 95 to 98 percent of the total gas, with smaller amounts of other gases such as H_2S, nitrogen (N_2), and trace amounts of methane (CH_4). There may also be trace amounts of mercury (Hg), boron (B), and arsenic (As) present in both the gas and liquid phases of the geothermal fluids. The gas composition estimate is based on the type of volcanic reservoir rocks in the area and the gas content at the Medicine Lake, California, geothermal field. This estimate is shown in Appendix F-2. These gases, in addition to air (from the turbine gland seals and general air in-leakage), would collect in the condenser and would need to be removed in order to maintain proper condenser vacuum. The gases would then be routed to the liquid redox system for H_2S removal. H_2S is the gas of primary concern and is expected to require abatement (see Section 4.5, Climate and Air Quality).

There are several types of liquid redox systems commercially available for H_2S removal. CEE expects to evaluate several types of removal systems. In a liquid redox system, the noncondensable gases (removed from the condenser) are brought into contact with a "redox solution." The solution selectively oxidizes the H_2S to form elemental sulfur. The elemental sulfur is filtered from the solution to form sulfur cake and is collected in a covered container and shipped off-site to be sold as a product for agricultural fertilizer or chemical processes. The redox solution is continuously regenerated by exposing the liquid to air. The expected H_2S removal efficiency for these systems is over 98 percent.

H_2S is the only emission that would be abated by the liquid redox system. Mercury, if present with the noncondensable gas, would be removed upstream from the system in a carbon filter. The filter would prevent mercury from concentrating in the sulfur cake. The gas remaining after the liquid redox system would consist primarily of carbon dioxide and would be vented through a stack approximately 14 to 18 meters (45 to 60 feet) tall.

Hazardous Materials Used and Generated During Utilization. Potential hazardous materials which would be used or generated during operations include petroleum products (e.g., gasoline, diesel fuel, oils, greases, brake fluid, transmission fluid/oil), acids/bases/oxidizers (e.g., battery acid, sodium bicarbonate, liquid bleach, polymaleic acid, silica inhibitors, biocide, caustic flake), solvents (e.g., kerosene, antifreeze, liquid gasket remover, starting fluid, degreaser, cleaning solvent), miscellaneous cleaners (e.g., detergents, soaps, disinfectant, furniture polish, floor wax stripper), and a biocide that will be used to prevent algae growth in the cooling towers. Welding gases (e.g., acetylene, oxygen, argon, nitrogen) are also potential materials to be used in operations.

Plant maintenance equipment includes turbines, compressors, trucks, cranes and road maintenance equipment. Materials expected to be used in this area are included in Table 3.14-2 and in Appendix H (Table H-2, Chemicals Used and Waste Generated: Plant Maintenance). Anticipated waste streams are the same as for drilling operations, excluding cuttings.

Chemicals which may be used during production/field gathering include oxidizers. Anticipated waste streams include: paper waste, used chemicals, and excess geothermal fluids. These are described in greater detail in Appendix H (Table H-3). Sample Material Safety Data sheets (MSDSs) for chemicals associated with the production/field gathering system are also included.

The H_2S abatement system would potentially use acids/bases/oxidizers and natural material (activated carbon) types of chemicals (see Appendix H, Table H-4). This process converts chemicals present in the noncondensable gas into elemental sulfur and water, which are considered nonhazardous.

Potentially hazardous materials may also be used in the facility's laboratory (see Appendix H, Table H-5). These chemicals would be stored in relatively small quantities. Proposed disposal methods include dilution and injection into wells with the brine A hazardous materials plan would be prepared and sent to the ODEQ for approval. The plan would identify all waste streams and the selection of management schemes which would minimize these streams and identify specific but appropriate disposal methods. Before injecting fluids that contain contaminants-of-concern, a quantitative analysis of the fluids would be completed where design and/or engineering controls are not feasible and sent to ODEQ for approval.

2.4.1.5. Decommissioning

Decommissioning is expected to take place 50 years or more after commencement of the project operations. Although there could be component parts of the project that could be decommissioned sooner, the main power project is planned for at least a 50-year project life. Factors which could extend the life of the project include an increase in the selling price of the geothermal energy, modifications to the proposed facility which would increase the production capacity of the wells, the ability to access geothermal fluid with existing wells, or a decrease in the cost of production. Other factors that could extend the operational life of the project include continued demand for power, extension or renewal of the power contract, and reservoir longevity. It is possible that the facility may continue operating while some of the wells may be shut down. Closure of the facility itself may, therefore, be deferred to some other point in time.

The closure activities considered in this section must be viewed as preliminary since they are subject to change over time as environmental engineering techniques evolve and more definitive information is developed during the life of the project. A final plan for permanent closure of the project would be submitted to BLM and the U.S. Forest Service at least two years prior to the anticipated cessation of operations. These plans would describe whether any of the facilities would continue to be used, how impacts to the geothermal resource, surface water, groundwater, and other resources, would be minimized, how the materials would be recycled, and how the site would be restored to acceptable conditions.

During decommissioning, all structures and equipment would be dismantled and removed, and the environment would be restored to pre-project conditions, or to conditions acceptable to the U.S. Forest Service and BLM. Transmission lines and support poles might also be dismantled and removed. The substation at LaPine would likely continue to service the area. The recycling or reuse of materials such as scrap metal would depend on the market and existing technology. Installed piping, well casings, well heads, and valves would probably be unsuitable for reuse and would require disposal.

Plugging and abandonment of all geothermal wells must comply with GRO Order No. 3. Basically, this order states that CEE must plug and abandon any well that is not in use and no longer demonstrates a capacity for further profitable production. The order outlines the manner in which the wells are to be abandoned and the surface area is to be restored.

Both the BLM and the Oregon Department of Geology and Mineral Industries (DOGAMI) require a bond to be posted prior to commencement of drilling operations. If the bond posted for the BLM meets DOGAMI's requirements, it does not have to be duplicated. The bond will ensure compliance with the terms and conditions of the lease, including plugging and abandonment of wells and site restoration (43 CFR 3206; ORS 522.145). If the developer goes bankrupt, the BLM can draw on the bond.

As a condition for obtaining a license for an electrical generating facility, CEE must furnish and maintain a bond of at least $100,000. The bond will be large enough so that, "Upon the relinquishment, expiration, or termination of the license, the licensee shall, if directed by the authorized officer, remove all structures, machinery, and other equipment from the land covered by the license. Removal of such property shall be at the licensee's expense" (43 CFR 3250.9.c).

"Where land covered by a license has been disturbed, the licensee shall within one year following the relinquishment, expiration, or termination of a license issued under this part restore the land in accordance with the terms and conditions of the license. The bond ...shall not be released until the reclamation has been completed to the satisfaction of the authorized officer [the BLM]" (43CFR3250.9.e).

The amount of the bond covering power plant decommisioning will be determined by the BLM when the final project design has been completed. A more accurate cost estimate for removal and site restoration can be made at that time. The BLM can adjust the bond amount at any time in the future if conditions warrant.

The Oregon Energy Facility Siting Council (EFSC) may also establish requirements for decommissioning as part of the state permitting process. These requirements are developed on a project-specific basis, and are not known at this time.

Further details regarding unit bonds and other bonding requirements can be found in 43 CFR Part 3200, available from the BLM. State regulations are available from DOGAMI and EFSC.

2.4.1.6. Project Schedule

The proposed project schedule is shown in Table 2.4-3. If approved, the proposed project would begin in September 1994, or after the Records of Decision are finalized. The initial project work would involve exploration activities such as construction and/or improvement of roads, well pad construction, drilling, and well testing.

In the initial drilling season (September through December 1994), one deep exploration drilling rig and one truck-mounted drilling rig (for drilling temperature gradient wells and core holes) would be in the field. Project activities would be expected to be restricted by winter weather from December to March on the initial well drilling. Drilling would continue as long as weather permits. The first pads would be constructed at locations north of Paulina Creek.

Project activities would resume in the spring of 1995, possibly March, depending on snow depth. A second deep exploration drill rig and a core hole rig would resume drilling in June 1995, depending on weather. Exploration drilling would continue into the field operation stage (through approximately the year 2000) as wells are drilled to define the extent of the resource.

Development activities — pad construction, drilling, and construction of the power plant, pipelines, and transmission line — would begin after a sufficient number of productive wells were drilled to define the characteristics of the resource. Power plant construction (site excavation and grading) could begin as early as October 1995. Depending on weather conditions and access to the project area, plant site excavation might occur in the spring of 1996.

Operation of the power plant would begin as early as late 1996, depending on the schedule of exploration and development activities. The plant would operate over the 50-year life of the power sales contract, although, there is the possibility that the plant would continue to operate under an extended contract or a new contract.

Decommissioning of the plant would occur at the end of the contract, after 50 years, depending on the life of the contract, the need for power, and the other factors discussed under decommissioning (see Section 2.4.1.5). Decommissioning would not necessarily occur at 50 years, but would occur at the end of the life of the project.

2.4.1.7. Summary of Mitigation Measures to Reduce Environmental Effects, Included as Part of Alternative A

The following mitigation measures to reduce environmental effects are included as an integral part of Alternative A's project design. These measures are based on CEE's operating experience and the environmental issues they recognized at Newberry. The measures are grouped by topic in the order in which the environmental topics are addressed in Chapters 3 and 4.

Geology and Soils

- All grading of the sites would result in a balanced cut and fill, with no soil import or export required.
- If required, additional lay down areas would not be graded, and vegetation would be crushed or cropped and would be rehabilitated upon completion of construction.
- Where possible, drill sites would be confined to minimize ground disturbance.
- Well testing facilities would be constructed on previously cleared areas (well pad).
- Cut and fill slopes would be engineered and terraced according to height and compacted and maintained to minimize erosion and provide slope stability.
- Geotechnical studies would be performed prior to plant construction to ensure site stability; recommendations of the studies would be incorporated into plant and facility design.
- Facilities would be designed to meet or exceed Uniform Building Code design methods for the local seismic zone.
- Project construction would include culverts, berms, and ditches to direct runoff and minimize erosion potential.
- Surface disturbance would be minimized by limiting operations to designated areas approved by the U.S. Forest Service.
- Sites posing potential geologic hazards (e.g., landslides) would be identified and avoided during facility siting.
- Facilities would be located near or within existing clear-cut areas when practical.
- Fluids produced after separation and cooling tower blowdown would be reinjected to (1) maintain reservoir pressure, (2) reduce surface discharges and disposal, and (3) reduce the potential to induce seismic activity from fluid withdrawal.
- Upon site abandonment, grades would be contoured and revegetated to their original conditions, where practicable.
- Gravel or other road materials necessary for improvement or repair of existing roads or construction sites would be obtained from existing road material pits, with concurrence of the U.S. Forest Service.

Water Resources

- All water withdrawal requirements (e.g., water for drilling/coring activities, watering roadways) would be coordinated with and subject to approval by the Oregon Department of Water Resources.
- Temporary above-ground pipelines would be laid along existing roads or other appropriate routes, from the well to the drill site, and between drill sites, to minimize surface disturbance.
- If a sump is filled during drilling, additional drilling fluids would be routed to another sump, piped to an injection well, or drilling would be suspended until additional fluid could be properly disposed of.

- The power plant and production well pads and pipelines for the proposed project would be sited to preclude the need for routing pipelines or roads across Paulina Creek (the three wells south of Paulina Creek are for exploration only under the project and would not require pipelines to the power plant site).

- The transmission line route would be sited to avoid Paulina Creek.

- The power plant design would allow for the produced fluids to provide most of the required operating water.

- Portable sanitary facilities would be used during construction to avoid impacts to water quality.

- Sanitary facilities for the plant site would include an engineered septic system, including a septic tank and leach field, to avoid impacts to groundwater.

- All production and injection wells would be sealed and cased to at least 610 meters (2,000 feet) depth to avoid impacts to groundwater.

- Drilling wastes would be contained in sumps lined with clay to prevent percolation of fluids into groundwater.

- Excess geothermal fluids would be contained in lined ponds at the power plant site prior to injection into the geothermal reservoir.

- Pads and facilities would be designed to direct drainage to sumps and to contain any spills on site, especially around the drill rig operating area.

- Stormwater runoff from curbed or bermed equipment areas in the power plant operating area would be collected in storm drains and routed to an oil/water separator. After oil is removed, the stormwater would be routed to the water storage pond at the plant site. The storm drain system would be designed to contain runoff from the 100-year return frequency storm. Storm runoff from other nonoperating areas (such as parking lots and equipment storage areas) would be directed to appropriate drainage channels through energy dissipaters.

- The power plant pond would be engineered such that the pond would overflow through an engineered overflow structure to a natural drainage way.

- All tanks containing materials such as diesel fuel, lubricating oils, scaling and corrosion control chemicals, cleansers, solvents, and any other hazardous substances or chemicals would be installed above ground and provided with secondary containment (such as curbs or berms around tanks). The secondary containment would have a capacity equal to 100 to 150 percent of the maximum spill volume.

- All drilling fluids would be formulated from non-toxic components and drilling effluent would be below the EPA end-of-pipe toxicity limit.

- Geothermal fluids produced during well production and drilling would be injected into the geothermal reservoir, evaporated in sumps, or disposed of at suitable offsite locations.

- An Emergency Contingency Plan would be established for accidental spills or discharges. It would be submitted to state officials for review and approval.

- Withdrawal of shallow groundwater would be down gradient from, and is not expected to interfere with, the groundwater table in the caldera. Geothermal fluids would be produced from a depth (approximately 1,829 to 2,743 meters [6,000 to 9,000 feet]) that would have no impact on shallow groundwater.

- Wastewaters from operations would be evaporated, injected, or otherwise disposed of in a manner approved by the ODEQ.

- No site runoff would drain to Paulina Lake; no site runoff would drain directly to Paulina Creek.

- CEE will continue hydrology monitoring.

Geothermal Resources

- The project would be designed to allow for return of produced geothermal fluids to the geothermal reservoir to maintain reservoir pressures and fluid production volumes.

- Groundwater from water wells may be used to supplement injection of produced fluids, enhance production, and maintain reservoir pressures.

- Proper well drilling and casing programs and the use of blowout prevention equipment would be used to minimize the potential for uncontrolled blowouts.

- Brine and excess condensate would be injected into the geothermal reservoir.

- Production wells would be spaced to minimize interference between wells and to sustain reservoir production.

- Geothermal reservoir monitoring would be maintained during production to monitor any changes induced by the project.

Climate and Air Quality

- Construction sites would be watered to minimize construction-related dust.

- Road watering, dust abatement, surfacing, and paving (if necessary) of facilities would reduce fugitive dust emissions. With the approval of the authorized officer, produced fluids would be used for dust control.

- Well testing and geothermal steam emissions would occur using the minimum time necessary to gather the required data on potential geothermal steam and noncondensable gas constituents.

- The power plant design would include control of noncondensable gases through the gas treatment system. This treatment system would include a liquid redox system to abate H_2S.

- CEE would continue to monitor existing meteorological stations and monitor for H_2S at the power plant site.

- Recirculation of cooling tower waters would be controlled to minimize build-up and emission of chemical constituents.

- Cooling towers would be oriented at the plant site to maximize the dispersion of cooling tower emissions.

- Condensers which provide maximum separation of H_2S gas from the steam would be utilized. The use of surface (rather than direct contact) condensers would minimize emissions of chemical constituents from the cooling towers.

- Electronic well field controls would minimize the duration of venting when the power plant was not operating.

- An emissions control plan would be developed for the power plant which would include procedures for upset and breakdown conditions.[1]

- In the event of steam venting from upset of plant operations, steam production would be trimmed back to reduce H_2S emissions 50 percent within the first hour and 25 percent of full flow after 6 hours. If after the second reduction other air quality problems persist, the wells would be shut back further to prevent further problems.

- H_2S concentrations would be monitored near the plant site and at an appropriate site near Paulina Lake or Paulina Lake Lodge.

- Plant operations would be logged to document actual frequency and duration of upset conditions. This information would be used in conjunction with monitoring of meteorology and H_2S concentrations to evaluate the effectiveness of H_2S abatement systems. If significant impacts are measured, additional mitigation would be required that is acceptable to the agencies.

Visual Resources

- The proposed power plant site was sited to minimize its visibility from Newberry Caldera and from Highway 97.

- The cooling towers would be designed to minimize the size and duration of the steam plume.

- Well pads and plant facilities were sited in clear-cut areas where possible.

- Facilities would be painted to blend with surrounding colors.

- The transmission line was sited along Road 9735 to minimize clearing and the need for new access roads.

- The proposed power plant site was selected to use topographic shielding of the facilities.

- Well testing (which results in steam plume) would be kept to the minimum time necessary to gather required data.

Noise

- Power plant facilities would be contained inside of a building which would reduce noise impacts in the surrounding areas.

- Mufflers would be installed on exhaust stacks of all diesel or gas-driven vehicles.

- Vehicle operations would be restricted to established roads.

[1] An upset or plant trip is a rapid, unscheduled power plant shutdown. It could be caused by mechanical problems or equipment failure in the plant, or by a transmission outage.

- Noise levels would not exceed 65 dBA at the lease boundary, or 0.8 km (0.5 miles) from the source, whichever is greater (in compliance with GRO Order No. 4).

Land Use

- Project characteristics would be consistent with the Deschutes Forest Plan and Newberry National Volcanic Monument Management Plan to the extent required by the Monument legislation.
- There would be no project facilities in the Special Management Area.

Recreational Resources

- Facilities were sited to avoid conflicts with recreational facilities, minimize the visibility of project facilities, and avoid crossing Paulina Creek.
- CEE would provide tours of the facilities.
- CEE would provide expansion loops, bridges, or assistance with trail rerouting, to avoid conflicts with snowmobile or Nordic ski use.

Traffic and Transportation

- Facilities were designed to take advantage of as many existing roads as possible to minimize construction of new roads.
- The transmission line was sited to be as close to Road 9735 as possible to minimize new spur roads and minimize maintenance requirements in the winter.
- To the extent practicable, well pads would be located along existing logging roads.
- A road maintenance agreement would be made with the U.S. Forest Service.
- Roads would be located on approved slope and land types.
- Project-related roads would be recontoured and restored at the time of field closure, as required by the U.S. Forest Service.
- Roads would be restored to a natural setting according to U.S. Forest Service standards once the project is decommissioned or if individual roads are deemed unnecessary.

Vegetation

- Gathering and injection system pipeline corridors would be routed through existing cleared areas, where practical. After construction, these corridors would be allowed to revegetate, where practical.
- Facilities would be sited on existing logged areas where possible to minimize disturbance.
- Brush and topsoil would be stockpiled for later restoration efforts.

Wildlife

- The transmission line would be designed to avoid hazards for raptors.

- Operations would be confined to designated areas to minimize unnecessary surface disturbance.

- Drilling fluids would be confined to steel tanks or lined sumps.

- Brush and topsoil will be stockpiled, where practical, for later restoration efforts.

- Sumps would be fenced to prevent wildlife from contacting toxic substances.

Cultural Resources

- Identified cultural resource sites would be avoided for siting well pads, power plant, roads, pipelines, or other surface disturbance. If previously undocumented sites are discovered during construction, activities would be halted until the resources are examined by a professional archaeologist and direction is given on how to proceed.

Human Health and Safety

- Removable winter enclosures would be provided to protect certain equipment and to provide clear access.

- Heat tracing equipment would be provided on piping that has the potential to freeze.

- Upon completion of temperature gradient holes, the wellhead gate valves would be chained and locked to prevent unauthorized access.

- Wellhead cellars would be covered with heavy-duty timber and nailed shut.

- All drilling operations would be conducted in compliance with the Federal GRO Orders Nos. 1-5.

- All wells would have blowout prevention equipment installed during drilling.

- All wells would have H_2S detection equipment and alarms to protect drilling personnel.

- All chemical injection systems installed at the well pads would be placed in a concrete or asphalt bermed area to contain potential spills.

- Hazardous materials would be handled according to all applicable regulations and requirements to minimize hazards to workers and the environment.

- Hazardous materials would be stored in areas with secondary containment features.

- The power plant buildings would be constructed of nonflammable or flame retardant material.

- The Plans of Utilization would incorporate the general fire protection and suppression of the U.S. Forest Service Region 6.

- Spark arresters would be used on all potential spark-emitting equipment.

- CEE would provide and maintain fire-fighting equipment at the project facility.

- A 15-meter (50-foot) fire break would be cleared around the plant site perimeter (fence).

- Restricted areas (e.g., hard hat areas) would be identified throughout the project site.

- Thermal expansion loops would be provided on all pipelines.

- The power plant facility would have an emergency shut-in program in the distributed control system which would allow the operator to shut-in a single well or all wells simultaneously in an emergency situation.

- An emergency diesel generator would be provided to supply emergency power when the unit was shut down.

- The plant perimeter would be bermed and secured with a chain link fence to prevent access from fauna and recreationists in the local area.

- The main access road and local spur roads to the production well pads would be plowed in the winter to remove snow.

Economic and Social Characteristics

- CEE proposes no mitigation at this time.

2.4.2. Alternative B

As described in Section 2.2, the range of alternatives for this project is limited and defined by the purpose and need for the project. Alternative B was designed to respond to the issues, minimize environmental effects, and ensure that all potential effects due to the siting of project facilities are addressed. Alternative B would include the same mitigation that is described in Section 2.4.1.7 above as being part of Alternative A, plus other specific mitigation measures that would further reduce potential adverse effects.

Alternative B was designed to address the following issues:

- Provide siting flexibility for most efficient use of the geothermal resource

- Provide siting flexibility for limiting surface resource disturbance

- Reduce visibility of the transmission line to the public

- Be compatible with any future modifications to Road 9735

Alternative B is similar to Alternative A in that it includes a 33-MW power plant on CEE leases at Newberry, with a 115-kV transmission line to bring the power to the existing grid. Development would occur according to the same project phases and schedule as described in Alternative A.

The primary differences between A and B are summarized in Table 2.4-6.

Table 2.4-6 Differences Between Alternatives B and A

Alternative B	Alternative A
Drilling could occur at 14 of 20 possible sites. Drill pads would be specifically sited at a later date within a 16.2-hectare (40-acre) siting area.	Drilling could occur at 14 of 14 proposed sites. Drill pads would be located at the specific site proposed.
Power plant would be constructed at one of three potential siting areas 12 hectares (30-acres) in size.	Power plant would be located at the specific site proposed.
Transmission line route south of Road 9735; single-pole structures. 22.8-meter (75-foot corridor) feathered to 38 meters (125 feet).	Transmission line route adjacent to the north side of Road 9735; H-frame structures. 30-meter (100-foot) corridor.
Underbuild feature to supply power to the plant and potentially to areas in the caldera.	No underbuild.

2.4.2.1. Well Pads and Sumps

The same type of well pads and sumps would be constructed under this alternative as under Alternative A. However, Alternative B proposes six additional locations to analyze and consider for the siting of the 14 well pads (Figure 2.4-21). Thus, although the number of pads actually constructed is still 14, the agencies and CEE would have 20 potential locations from which to choose the 14 sites. This would allow for greater flexibility in the designation of the 14 permitted pads, would increase the likelihood of avoiding any sensitive areas, and would help the operator place wells at locations to make best use of the geothermal resource. In addition, the pads would be located within larger siting areas ranging in size from approximately 8.1 to 16.2 hectares (20 to 40 acres). The larger siting areas are shown in Figure 2.4-21. The portion of each siting area actually available for a well pad is limited to the part within the SO lease area. Well pads will not be permitted in the NSO lease area (the SMA), which is shown on Figure 2.4-21. The larger siting areas, shown as squares on Figure 2.4-21, represent the probable zone of influence of a developed well pad on wildlife species sensitive to disturbances (such as noise, human presence) that were identified by the U.S. Forest Service and ODFW wildlife biologists who provided substantial input into the design of the baseline study. This is why some well pad siting areas extend into the NSO lease area (SMA). The pads' being located in the larger siting area would allow for minor shifts in pad locations to accommodate resource constraints and engineering and environmental concerns. The rationale for this siting flexibility is described below.

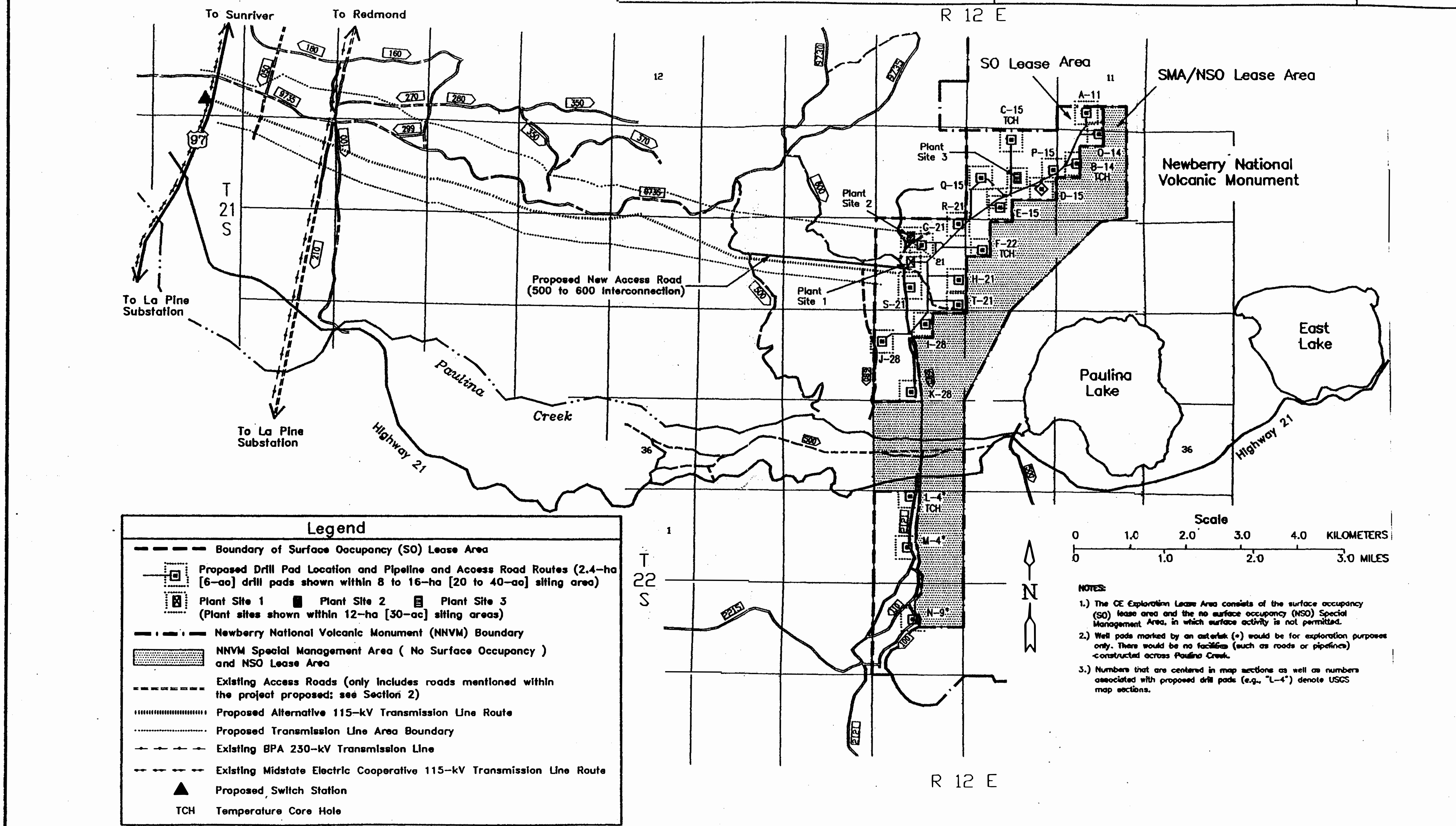
Geothermal Well Siting. The well pad locations initially proposed by CEE were chosen based on initial drilling targets determined through geologic mapping, geophysical studies, existing well data, and other research. The locations of the pads (and attendant roads and pipelines) are determined by:

- Geologic drilling targets
- Terrain
- Sound engineering practices
- Environmental concerns
- Plume dispersion
- Results of exploration and production drilling
- Lease stipulations

NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

Alternative B, Newberry Geothermal Pilot Project

Figure 2.4-21



Frequently in geothermal exploration and development, the subsurface geologic information about rock type, fractures, permeability, and porosity that is gathered during the drilling of each well provides strong rationale for siting the next well pad and drilling location. The drilling targets (subsurface fracture zones) can change after exploration begins (and even during development drilling), because real, site-specific information becomes available to supplement pre-project assumptions and estimates. This often results in requests from the developer to shift or relocate pads to access the new drilling target.

Requests for shifts in pad location can also result from site-specific engineering or resource concerns that may emerge during the project. For example, the pad construction contractor could suggest a somewhat different pad orientation or location to minimize cut and fill or to ensure balanced cut and fill (which eliminates the need for additional movement of soil and rock). In the future, requests to shift pad locations could be based on minimizing site-specific disturbance or effects on biological or other resources.

Siting Authorization. Under Alternative B, prior to constructing each well pad, CEE would submit the location of the well pad to the U.S. Forest Service and BLM for their review and approval. CEE would base the specific location of the drill pad on geologic targets (i.e., the predicted locations of subsurface fractures that would produce steam), data from previous drilling, engineering constraints, and environmental considerations. The agencies would then review the proposed location to determine if there are any environmental or siting considerations and, if acceptable, approve the location. If the proposed location was not acceptable, the agencies would identify an alternate location (within the maximum 16-hectare [40-acre] siting area) that would be acceptable.

2.4.2.2. Power Plant Location, Structures and Facilities

This element of Alternative B would differ from the corresponding elements of Alternative A in terms of where they would be located or "sited." The actual structures and facilities that would be developed under this alternative would be the same as those described under Alternative A. The differences from Alternative A are described below.

Power Plant Location. Alternative B includes two changes related to power plant siting. This alternative addresses two alternate power plant sites, in addition to the plant site location proposed in Alternative A (see Figure 2.4-21). In addition, each of the three plant sites (i.e., the proposed location plus the two alternate locations) could be located within 12-hectare (30-acre) siting areas at each location. Only one plant site would be developed. The final location would depend on engineering concerns, location of the productive well pads, and environmental considerations of the three sites.

These plant siting alternatives were designed to provide greater flexibility in siting the power plant after the geothermal resource is defined. Greater flexibility in siting would be desirable to minimize potential environmental effects. This flexibility would also be advantageous to the agencies since it would allow another site-specific review of facility locations and the opportunity to further minimize environmental effects before approval is granted.

The alternate plant sites were selected to allow for the possibility that the productive wells could be located primarily at the northern end of the lease. Plant locations farther to the north, and hence potentially closer to the productive wells, could minimize pipeline length and the amount of surface disturbance needed.

Siting Approval Process. The final location of the power plant would be proposed by CEE within one of the three plant siting areas analyzed under this alternative. CEE would base this proposal on the location of the productive wells, the engineering at the site, dispersion modeling, economic viability, and other factors. The agencies would then consider the proposed location and review the environmental constraints as identified and addressed in this EIS. The agencies would have to approve the final plant location before construction could begin.

Structures and Facilities. The power plant structures and facilities under Alternative B would be the same as those described in Alternative A.

2.4.2.3. Access Roads

The access roads required for Alternative B would be similar to those described in Alternative A. The primary difference in Alternative B is in the road from the power plant to Road 9735, and the route paralleling Road 9735 to Highway 97. Under this alternative, Spur Road 500 and the transmission area road would be used as the main access road to the power plant (if Plant Site 1 were selected) from Road 9735. The main access road and the transmission line corridor would be located in the same corridor to the extent practical until the transmission line corridor intersects Spur Road 500 and then the main access road would follow Spur Road 500 to Road 9735 (Figure 2.4-21). (Under Alternative A, the transmission line access road follows Road 9735 and then follows Road 600 to the plant.)

For the transmission line under Alternative B, an access road would be built within the transmission line area. Access to the area from Road 9735 would be via short access spurs across existing logging units. Existing logging access spur roads could require extensions of about 0.4 km (0.25 miles) to the transmission line area. Final locations of roads would be based on final engineering design of the transmission line and the road locations would be approved by the agencies.

2.4.2.4. Pipelines

This aspect of Alternative B would be very similar to that of Alternative A. Under this alternative, however, alternative pipeline corridors would be evaluated to address the six additional potential well pad locations. The total length of pipelines would be very similar to that of Alternative A, with slight differences in length that would be determined with the final locations of the well pads.

2.4.2.5. Power Transmission Line

There are several elements of this aspect of the project that would differ from Alternative A. Under Alternative B:

- The transmission line location would be an average of 122 to 152 meters (400 to 500 feet) south of Road 9735, and would be screened from view from the road by trees.

- Transmission line poles would be 21- to 24-meter (70- to 80-foot) single wooden poles (approximately 3 meters [10 feet] in the ground) rather than H-frame wooden poles (see Figures 2.4-15, 2.4-16, and 2.4-17) and would be less visible. A typical cross section of single pole transmission line design is shown in Figures 2.4-22 and 2.4-23.

- The surface disturbance for the transmission line area would result in a 22.9-meter (75-foot) wide area with trimming ("feathering") of trees in a 38.1-meter (125-foot) corridor.

- Spur 500 would be used as the main access to the proposed power plant site 1 from Road 9735.

- The transmission line could include a 25-kV underbuild to allow Midstate to provide the project with start-up and emergency power, as well as provide a future opportunity to provide electrical service to the Newberry Caldera.

Alternative B includes an alternative transmission line design and route to minimize environmental effects and to respond to the issues. The transmission line alternative was specified to:

- Move the transmission line away from Road 9735
- Reduce the visual impact of the pole structures
- Reduce the width of the cleared area

Route. The alternate transmission line route would be located between approximately 120 and 150 meters (400 to 500 feet) south of Road 9735, and farther from the road than the proposed Alternative A transmission line route. This alternate route would minimize the visibility of the line from Road 9735, which is expected to experience increased use. The route of the Alternative B line from Highway 97 to the switchyard would be as described in Alternative A.

Pole Design. The design of the line for Alternative B is single wooden poles, rather than the H-frame design proposed in Alternative A. The single-pole design would reduce the visibility of the poles and would require less surface disturbance to erect. These poles would be approximately 18 meters (60 feet) above ground. Figures 2.4-22 and 2.6-24 show this design of the transmission line poles. H-frame structures could still be used at angle points in the line where greater strength would be required.

Voltage and Underbuild. The transmission line under Alternative B would be 115 kV, as would the proposed line under Alternative A. Under Alternative B, however, the transmission line would include an "underbuild" feature (see Figure 2.4-24) The underbuild would be a second string of wires (underneath the 115-kV wire) that would carry electricity at a lower voltage. The 25-kV line would allow Midstate Electric to supply start-up and emergency power to the geothermal power plant. The underbuild line could be extended (in the future and after a separate environmental analysis) to provide power to the Newberry caldera area of the NNVM. This EIS only addresses the environmental effects of constructing the transmission line with the underbuild as far as the geothermal power plant. As in Alternative A, the transmission line would be designed to allow future expansion to about 100 MW without rebuilding the line.

Clearing. Under Alternative B, the clearing of transmission line corridor vegetation would be reduced to 22.8 meters from 30 meters (75 feet from 100 feet) proposed under Alternative A. Trees would be trimmed to increasing heights and feathered back 7.6 meters (25 feet) from the 22.8 meter (75-foot) wide corridor 38 meters (125 feet) (7.6 meters [25 feet]) on each side of the corridor). The construction corridor would be less than Alternative A; the reduced corridor size is a result of changing the transmission line poles from H-frame (Figures 2.4-15 and 2.4-17) to single-pole (Figures 2.4-22 and 2.4-23) design.

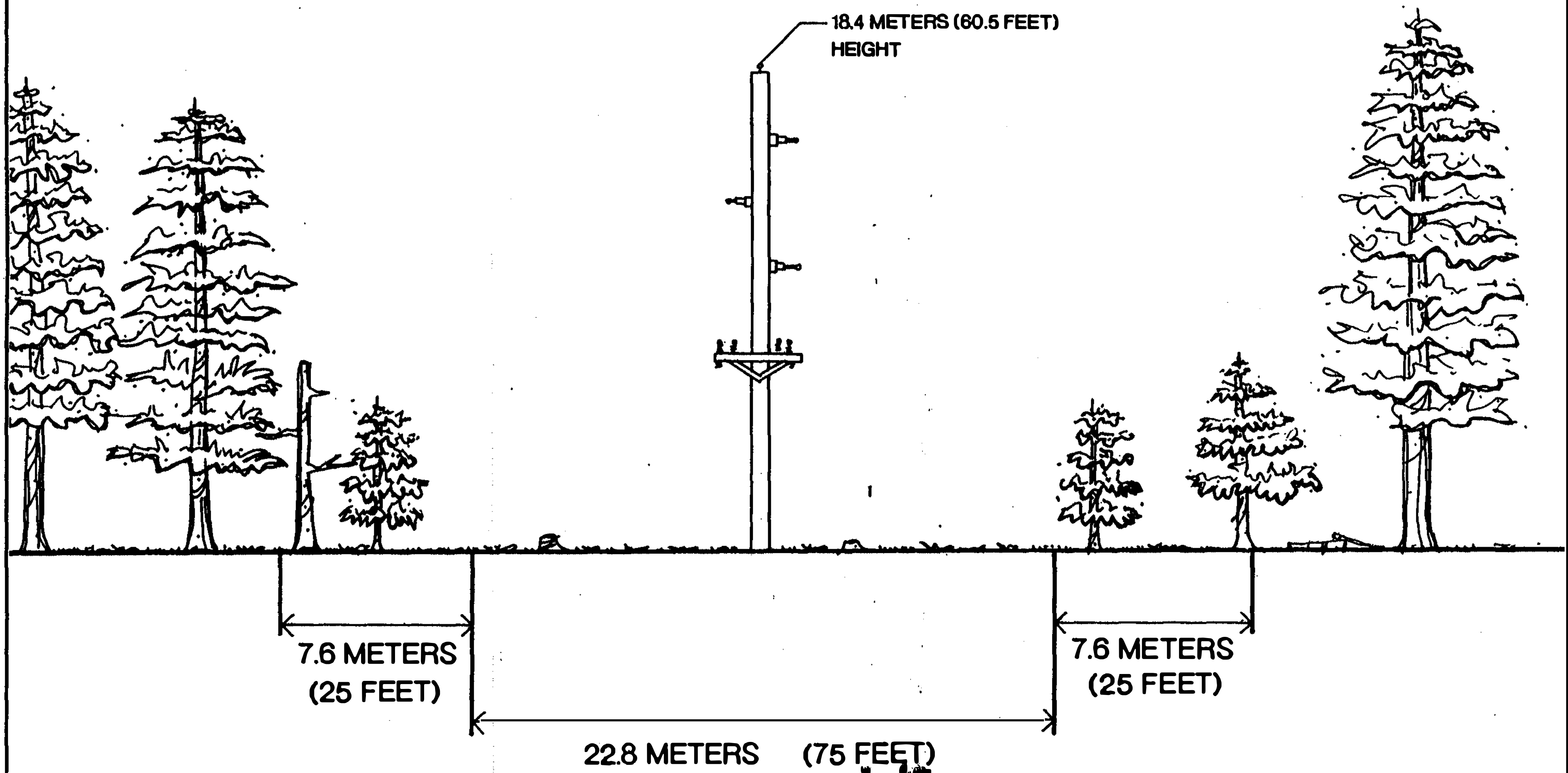
In some areas, the minimum safe clearing area would be 15 meters (50 feet) (7.6 meters [25 feet]) on each side of the centerline), with an additional 7.6 meters (25 feet) of tree feathering on each side of the corridor. The wider corridor would be in areas of greater fire danger and in higher elevation areas with more snow. The greater fire danger is in the higher elevations with lodgepole pine.

Feathering would consist of topping of trees, and complete removal of large trees that could pose a danger if they were to fall and hit the transmission line. The feathering would be maintained over the life of the power line. The agencies would approve the feathering plan, based on final design.

Voltage and Switchyard. The voltage of the transmission line under Alternative B would be 115 kV. The switchyard would be located in the same place and include the same features described under Alternative A.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Cross-Section of Western Portion of Transmission Line -- Alternative B	Figure 2.4-22

NOTE: A new adjacent access road would parallel the transmission line after it crosses Road 500 in the eastern part of the transmission line area.



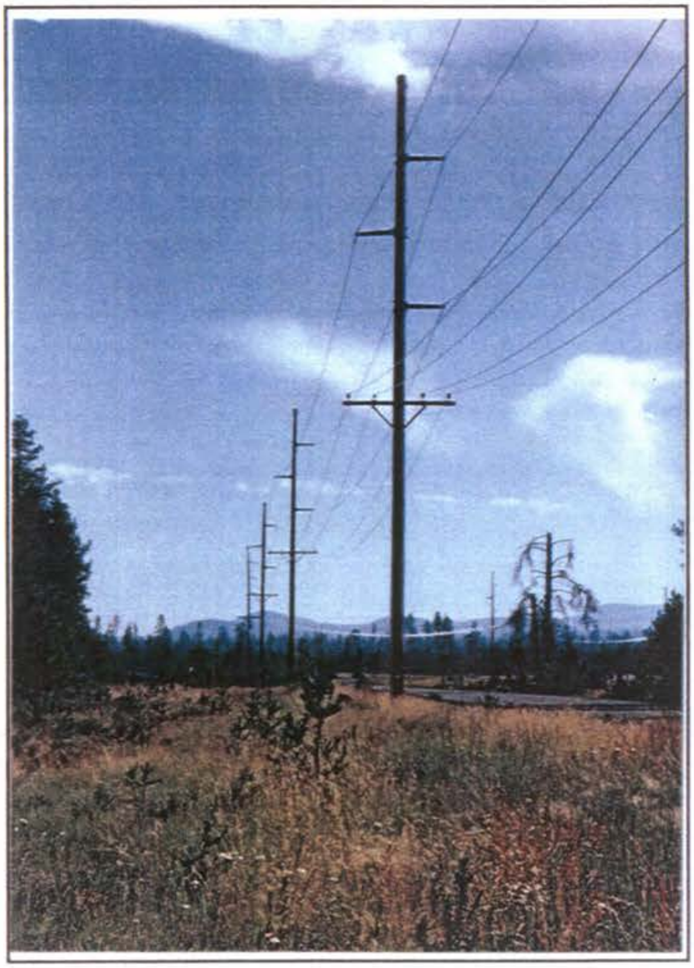
SCALE:

1 cm = 24 m

1 inch = 200 ft

Single Pole Transmission Line Photo

Figure 2.4-23



Example of the single pole construction proposed in Alternative B

2.4.2.6. Mitigation Included in Alternative B

Alternative B would include all of the mitigation that is included in Alternative A (see Section 2.4.1.6), with the exception of the measure relating to siting the transmission line as close to Road 9735 as possible. Alternative B would also include the following mitigation measures that are designed to further reduce environmental effects of this alternative.

Geology and Soils

- Exposed areas would be landscaped (including recontouring and revegetating) to stabilize soil and improve aesthetics, as appropriate.

- Construction traffic would be restricted to designated roads and areas to help reduce the potential for erosion and to reduce the amount of site disturbance.

Water Resources

- Storage facilities for fuel and construction equipment, lubrication oils, and the fueling area would be within a curbed or bermed area to contain any spilled material, and would be paved for permanent facilities.

- The septic system would be designed to have sufficient capacity for public tours and other visitors.

Geothermal Resources

- For elements related to water, water quality, geothermal features, etc., mitigation would be added that includes a hydrology monitoring program that has been established and would be continued, or a similar program that would be implemented by some other entity.

Climate and Air Quality

- Lichens would be monitored at points up to 1,500 meters (0.9 mile) from the plant site as indicators of air quality and potential impacts to vegetation.

- Establish an H_2S monitoring program at an appropriate site near Paulina Lake or Paulina Lake Lodge. This information would be used in conjunction with monitoring of H_2S emissions at the plant site to evaluate the effectiveness of H_2S abatement procedures.

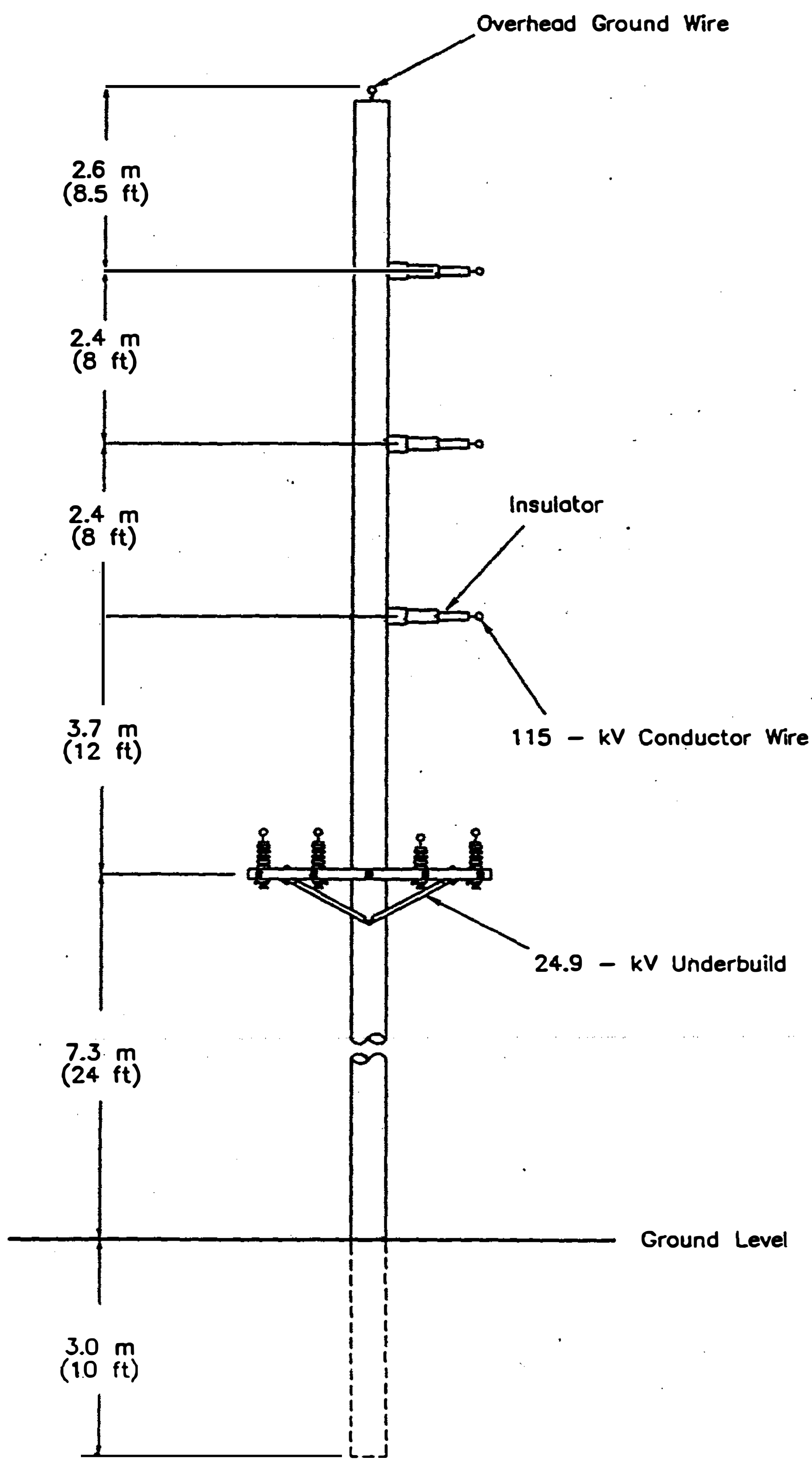
- Weather data at the two existing meteorological monitoring stations would continue to be monitored to better define and predict weather and wind patterns and their effects.

- Lichen tissue would be monitored and studied by U.S. Forest Service and compared to baseline information to test the prediction that air quality impacts to lichen and other vegetation is not anticipated.

- Chemical composition of the reservoir steam will be assessed to determine whether significant levels of mercury would be emitted by the power plant. If significant levels of mercury emissions are found, emission control system(s) will be added to the power plant.

- Plant operations would be monitored for actual frequency and duration of upset conditions.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical 115-kV Single Pole Design with Lower Voltage Underbuild	Figure 2.4-24



Visual Resources

- Trees would be planted in strategically grouped and selected locations to help break up or screen out visibility of the plant or other facilities.

- During construction of transmission lines and pipelines, land clearing for project facilities or structures would use curvilinear boundaries where practicable instead of straight lines.

- Brush or small trees cleared and not otherwise disposed of would be spread to provide cover habitat for small mammals, reptiles and birds. Woody materials would be randomly placed in areas to conform to adjacent vegetation patterns. All timber and other vegetation material without market value would be mechanically chipped and spread in a manner that would aid seedling establishment and soil stabilization.

- The use of the basic landscape elements for facility planning and design would be considered. This measure would be one of the most effective techniques to reduce visual impact of the project. Simplified structures and coverings would be used to enhance the overall appearance of the project area facilities.

- Creative landscaping would be applied in visible or sensitive areas to enhance the appearance of project facility installation. Selection of trees and other plants for landscaping would be based on their ability to blend with existing vegetation, utilizing native species where possible.

- Night lighting would be selected and designed to reduce potential visual impacts due to disturbance of the night sky. Exterior lights would be adequate for safe working conditions and security of the facilities.

- Colors of the facility would be chosen to blend with the surrounding landscape.

Recreational Resources

- A new Snow Park would be constructed at a location which would not conflict with operations and maintenance of the geothermal facilities but would take advantage of vehicle access to this area in the winter time. Additional trails could be developed from this location. Site selection, size, design, maintenance, and management would be determined by the Deschutes National Forest, in cooperation with representatives of local Nordic ski and snowmobile clubs and the operator.

- The facility would be available for public tours by appointment.

- Displays or other interpretive avenues would be developed in cooperation with the U.S. Forest Service to provide information to the local population and visitors to the area about the geothermal resource at Newberry, the geothermal project and its facilities, and the management of geothermal on the Deschutes National Forest. These would be available for display at existing facilities (interpretive centers, visitor sites, etc.).

- Snowmobile Trail No. 64 would be rerouted as needed to assure continuity of travel.

- Any recreation trails which may be planned in the future would be located to avoid possible conflicts with the geothermal facilities.

Vegetation

- The amount of vegetation removed would be minimized by limiting travel routes, parking areas, and other site disturbance to as small an area as practical.
- Disturbed areas would be revegetated with natural or assisted revegetation, including the use of native or local grass, shrub, and tree species.
- Construction activities at well pads A-11, B-14, and 0-14 would avoid disturbing larger mixed conifer trees to the extent possible.
- Lichens would be monitored at points up to 1,500 meters (0.9 mile) from the plant site as indicators of air quality and potential impacts to vegetation.

Wildlife

- Active raptor nests located during the exploration and development phases would be protected in compliance with in compliance with the Forest Plan direction.
- Monitoring would be performed during the exploration and development phases to determine location of active nests, to track nesting success, and to protect nests from disturbance.
- Where possible in the mixed conifer habitat along the transmission line, live trees would not be felled if greater than 51 cm (20 inches) and snags greater than 30.5 cm (12 inches) dbh[1].
- Where possible, stumps would be at least 3.6 meters (12 feet) tall to provide foraging habitat for insect-gleaning birds.
- Large trees would be topped instead of felled as a way to keep them from falling onto transmission lines. Topped trees would continue to provide suitable foraging and nesting habitat for birds.
- Vegetation would be feathered along the transmission line area both vertically and horizontally, to avoid long straight edges and the appearance of a cleared swath. The area would be revegetated with grasses and acceptable shrubs which would not impose a safety hazard to line maintenance, but would provide forage for wildlife.
- Larger size, downed woody material would be left in the transmission line area for wildlife use.
- Fencing would be constructed around the plant perimeter and around well pad sumps to keep out deer and other large animals.
- Water sources would be provided for wildlife at locations away from the power plant and well pads to help deter the animals from being attracted to the facilities.

2.4.3. Alternative C: No-Action Alternative

Under this alternative, no facilities would be developed, and the following Federal actions for authorizing geothermal activities or purchasing power would not occur for this project:

[1]Diameter at breast height (a measure of tree density)

- BLM and U.S. Forest Service approval of the Plans of Operations for exploration, development and production

- BLM issuance of individual Geothermal Drilling Permits

- U.S. Forest Service issuance of authorization for surface occupancy

- BLM and U.S. Forest Service approval of the Plan of Utilization and Disposal, including construction and operation of the geothermal generating facility or construction of associated pipelines and transmission lines

- BLM issuance of a two-part Geothermal Utilization Permit

- BLM approval of a Site License

- BPA execution of a contract to wheel power from the project to EWEB

- BPA power purchase contract with CEE

- BPA billing credit agreement with EWEB

Under this alternative, CEE could still propose another geothermal development project on the leases, and another analysis and NEPA document would need to be prepared to evaluate that proposal.

However, design modifications to the existing proposals could be considered, which might lead to geothermal development at Newberry under different construction and operation scenarios. Since geothermal is one of the energy resource options that BPA is considering, other locations for geothermal development would likely be considered. A discussion of these resource types and other means of meeting the required power load is found in the BPA Resource Programs Final EIS (BPA 1993).

2.5. COMPARISON OF ACTION ALTERNATIVES

This section summarizes the impacts of Alternatives A and B in comparative form, based on the information and analyses presented in Section 3, Affected Environment; and Section 4, Effects of Implementing Each Alternative. Table 2.4-1 shows the features of Alternatives A and B. Table 2.5-1 compares the environmental effects of Alternatives A and B. Alternative C is not described in a separate column on the table because the effects associated with construction and operation of the proposed project would not occur.

For a total of eight environmental disciplines, the potential impacts and mitigation measures of Alternatives A and B are identical, or nearly so, and are reported as such in Table 2.5-1. Those disciplines with very similar or identical impacts are water resources, geothermal resources, climate and air quality, land use, recreation, human health and safety, cultural resources, and economic and social characteristics.

There are differences, however, in impacts and mitigation between Alternatives A and B in the disciplines of geology and soils, visual resources, noise, traffic and transportation, vegetation, wildlife, cultural resources, and siting flexibility. These differences are summarized below in Table 2.5-1.

Overall, the effects of Alternatives A and B would be similar. The major differences are summarized below:

- Under Alternative B, the transmission line would not be as visible from Road 9735.
- Under Alternative B, there would be increased potential for avoidance of sensitive areas in well pad placement and to reduce the amount of pipeline and access roads needed.
- Under Alternative B, there would be increased potential for minimization of visual impacts of the power plant site.
- Under Alternative B, siting flexibility would allow for the most efficient use of the geothermal resource while minimizing environmental effects.

Table 2.5-1 Comparison of Effects of Action Alternatives

Discipline	Type and Magnitude of Alternative A Impacts	Type and Magnitude of Alternative B Impacts
Geology and Soils	Grading on gentle slopes during construction over 91 hectares (225 acres) for plant site, well pads, pipeline and roads; and 28.1 hectares (69.5 acres) for the transmission line area.	Grading area may be larger for gathering system, if well pads chosen are more distant than those under Alternative A, or less if pads are closer.
	Soil disturbance is minimized along transmission line owing to proximity of Road 9735 for much of its length.	Larger soil disturbance along transmission line for access where existing roads do not cross the line, and for new access to Plant Site 3.
Water Resources	Withdrawal of up to 3.08 million cubic meters (2,500 acre-feet) per year from shallow groundwater aquifers, representing approximately 1 percent of total groundwater recharge on the west slope of Newberry Volcano.	Same as A, except that potential changes in water quality and hydrologic patterns could be more widely distributed, depending on choices for power plant and well locations.
Geothermal Resources	Effects on hot springs in the caldera should be slight, subtle, and long delayed, if they occur at all. Maximum net fluid loss from reservoir estimated to be 1 to 2 percent per year, which should be at least partially made up by natural recharge.	Siting flexibility would improve efficient use of the geothermal resource. Other effects same as A.
	No siting flexibility. If test drilling results indicate that proposed well pads and/or other facilities are at inappropriate locations, additional environmental review and consequent potential delays could occur to the development process.	Additional power plant and well pad sites provide more flexibility in siting facilities to avoid sensitive areas, and based on the results of the test drilling, reducing chances of additional delays owing to the need for additional environmental review of new facilities locations.
Climate and Air Quality	Emissions for all regulated pollutants during the worst-case scenario and typical operations are expected to be well below applicable state and Federal standards set to protect human health and welfare.	Same as A, except that impacts at the NNVM boundary would be greater for Plant Site 3, which is closer than Plant Sites 1 and 2.

Table 2.5-1 Comparison of Effects of Action Alternatives (Continued)

Discipline	Type and Magnitude of Alternative A Impacts	Type and Magnitude of Alternative B Impacts
Visual Resources	Except for the power plant steam plume and well venting, facilities will not be visible from any key observation point (KOP), except for Paulina Peak and the Rim Trail. Plume will draw visual attention from Paulina Peak and Rim Trail. From more distant KOPs, plume will be visually subordinate to surrounding landscape and not generally noticed.	Steam plume, well venting, pads south of Road 21 effects similar. Power Plant Site 2 is slightly more visible from Paulina Peak (KOP 3) due to lack of visual screening in logged areas; this site is 0.8 km farther from the KOP, which compensates some for lack of screening. Power Plant Site 3 is less visible from Paulina Peak than Plant Sites 1 and 2.
	Well pads located south of Paulina Creek would be partially visible from Road 21.	The six additional well pads would have visual impacts similar to the 14 in Alternative A.
	Transmission line would be visible in clearcuts along Road 9735 and briefly from Highway 97. Night glow of power plant would be visible from Paulina Peak and its access road; dim night glow may be visible from more distant KOPs.	Transmission line corridor will not be as visible from Forest Road 9735, reducing potential impacts to a road corridor that may receive increased use in the future. Night glow would be less than Alternative A.
Noise	Impacts from slightly elevated noise levels and occasional sounds associated with drilling.	Lower power plant noise at potential noise receptors owing to more distant location of Plant Sites 2 and 3. Other differences imperceptible.
Land Use	Reduction of North Paulina Roadless Area by 6 percent. (This is the gross lease area, not the amount of surface disturbance.)	Same as A, except that Plant Site 3 would also be in roadless area.
	Removal of 119 hectares (295 acres) from the timber base in the Project Area.	Removal of approximately 123 hectares (303 acres) from the timber base depending on plant site and well pad selection.
Recreation	Changes to recreation experience to hunting and snowmobiling would be consistent with the Roaded Modified or Semi-Primitive Motorized (winter only) ROS designations assigned to the Project Area. Recreation experience could be affected at times when elements of the proposed project would be (infrequently) seen, heard, and/or smelled.	Same as A, except that Plant Site 3 would intrude into the currently roadless area.

Table 2.5-1 Comparison of Effects of Action Alternatives (Continued)

Discipline	Type and Magnitude of Alternative A Impacts	Type and Magnitude of Alternative B Impacts
Traffic and Transportation	Rebuild main entrance to project area by following Forest Road 9735 to Spur 500, connecting Spur 500 to Spur 600 along proposed transmission line corridor, requiring 1.6 km (1 mi) of new road along transmission line, extensive rebuilding of Spur 600; widening of Spur 500; new roads for well pads, access road along entire length of transmission line provided by Forest Road 9735.	During development, Spur Road 500 would be resurfaced and become main access road to Plant Site 1 or 2 requiring 1.6 km (1 mile) of new road along the transmission line and improving Spur 600 for exploration activities. Plant Site 3 would require about 3 km (2 miles) of new road construction along exploration roads. Additional length of road may be required if more distant well pads are chosen. Separate transmission corridor from Forest Road 9735 would be constructed, possibly needing additional access from Road 9735 at intervals along eastern portion of line via short spurs across existing logging units.
Vegetation	Removal of 7.5 hectares (18.5 acres) of lodgepole pine regeneration habitat at Plant Site 1.	Plant Site 1 is same as Alternative A. Removal of 7.5 hectares (18.5 acres) of lodgepole pine and lodgepole pine regeneration habitat for Plant Site 2. Removal of 7.5 hectares (18.5 acres) of lodgepole pine for Plant Site 3.
	For gathering system, removal of 36 hectares (89 acres) of vegetation, including 5.5 hectares (13.7 acres) of lodgepole-mixed conifer, 3.2 hectares (7.8 acres) of lodgepole/clearcut, 26.7 hectares (65.9 acres) of lodgepole, and 0.53 hectares (1.4 acres) of mixed conifer.	Approximately the same as Alternative A, depending on which well pad and plant site combination is used.
	For access roads, loss of lodgepole-dominated areas with portions of open ponderosa pine and mixed conifer habitats.	For access roads, removal of potentially slightly more vegetated area for access to the transmission line corridor if existing roads are not present.

Table 2.5-1 Comparison of Effects of Action Alternatives (Continued)

Discipline	Type and Magnitude of Alternative A Impacts	Type and Magnitude of Alternative B Impacts
Vegetation	For the transmission line area, removal of 28.1 hectares (69.5 acres) of vegetation, including 1.2 hectares (3 acres) of lodgepole/clearcut, 0.2 hectares (0.5 acres) of lodgepole pine, 8.1 hectares (20 acres) of mixed conifer habitat, 13.7 hectares (34 acres) of open ponderosa pine, 3.2 hectares (8 acres) of lodgepole pine regeneration, and 1.6 hectare (4 acres) of mixed conifer partial cut habitat. Partial removal (feathering) would affect approximately 9.4 hectares (23.2 acres) of vegetation, including 0.45hectares (1.1acres) of lodgepole/clearcut, 0.08 hectares (0.2 acres) of lodgepole pine, 2.5 hectares (6 acres) of mixed conifer habitat, 4.7 hectares (11.8 acres) of open ponderosa pine, 1.1 hectares (2.8 acres) of lodgepole pine regeneration, and 0.53 hectare (1.3 acres) of mixed conifer partial cut habitat.	For the transmission line, removal of 31.6 hectares (78.2 acres) of vegetation, including 1.5 hectare (3.6 acres) of lodgepole/clearcut, 2.2 hectare (5.5 acre) of lodgepole pine, 5.5 hectares (13.7 acres) of mixed conifer, 17.3 hectares (47.2 acres) of open ponderosa pine, and 3.3 hectares (8.2 acres) of lodgepole pine regeneration. Partial removal (feathering) would affect approximately 19.9 hectares (49 acres) of vegetation, including 0.97 hectare (2.4 acres) of lodgepole/clearcut, 1.5 hectare (3.6 acre) of lodgepole pine, 3.7 hectares (9 acres) of mixed conifer, 11.5 hectares (28.5 acres) of open ponderosa pine, and 2.2 hectares (5.5 acres) of lodgepole pine regeneration.
	For well pads, removal of 34 hectares (84 acres) of habitat, including 3.7 hectares (9.2 acres) of lodgepole/mixed conifer, 1.4 hectares (3.5 acres) of lodgepole/clearcut, 24.6 hectares (60.8 acres) of lodgepole, 0.2 hectare (0.4 acre) of mixed conifer, and 4.1 hectares (10.1 acres) of clearcut.	Removal at well pads could be of different vegetation composition, depending on pad sites chosen. Some shrub and mixed conifer habitat could be avoided.
	No discernible effects on vegetation beyond 500 meters (1600 feet) of the power plant except for the areas immediately adjacent to wells.	Same as A. Better avoidance of sensitive areas and mixed conifer vegetation through project design and siting flexibility.

Table 2.5-1 Comparison of Effects of Action Alternatives (Continued)

Discipline	Type and Magnitude of Alternative A Impacts	Type and Magnitude of Alternative B Impacts
Wildlife	Total 119 hectares (295 acres) of direct habitat loss or modification due to facility placement. (well pads, plant, and roads equal habitat loss. Transmission line and pipeline equal habitat modification.)	Habitat losses and modification similar to A; but more or less could occur in mixed conifer type under this alternative, depending on well pads chosen. Impacts from development of well pad O-14 could result in an additional loss of up to 2.4 hectares (1 acre) of deer/elk high use area, not including access road. Clearing width of transmission line is 7.6 meters (25 feet) narrower than Alternative A. Loss of approximately 7.5 hectares (18.5 acres) potentially suitable habitat for black-backed woodpecker (MIS) at Plant Sites 2 and 3.
Cultural Resources	Known resources can be avoided.	Same as A.
Human Health and Safety	Probability of accidents during transport of hazardous materials during exploration estimated at 0.238 percent. During utilization over 50-year project life, approximately 1 accident during transportation of hazardous materials estimated. Probability of project personnel-caused fires over 50-year life of project conservatively estimated at 8; this would be offset by benefits of personnel present 24 hours a day to spot, report, and assist in extinguishing fires.	Same as A.
Economic and Social Characteristics	Peak population increase of 447 persons during height of construction, and 50 persons during utilization. Construction jobs at peak would be 227 (60 local hires), during utilization 25 permanent jobs (12 local hires) would be created. Up to 60 additional students would be in Bend/LaPine School District during peak of construction. Royalties (approximately $240,000) and property taxes (approximately $1.2 million) would be raised annually.	Same as A.

3.0
AFFECTED ENVIRONMENT

3.1. INTRODUCTION

This section describes the environment that could be affected by the proposed Newberry Geothermal Pilot Project. It serves as the basis for discussion of environmental consequences of Alternative A, Alternative B, and Alternative C — the no-action alternative — which are presented in Chapter 4.0.

For purposes of this report, the terms *project area* and *project vicinity* are used to describe specific areas of central Oregon potentially influenced by the proposed project. *Project area* refers to that area encompassing CEE geothermal leases and the alternative plant sites, well pads, gathering systems, transmission lines, and access roads (i.e., those areas potentially directly impacted by project construction). *Project vicinity* refers to the project area, the entire Newberry National Volcanic Monument (NNVM) and north to the City of Bend (Figure 3.1-1). In addition, the term *study area* is that portion of those areas listed above which was included for investigation for each technical section or discipline. The extent of the study area can differ between disciplines (i.e., geology and soils, water resources, etc.) and thus is defined in each section. Study areas defined for each discipline were those areas in which impacts could reasonably be expected to occur. The lease area is divided into an SO lease area (where surface occupancy is allowed) and NSO lease area (No Surface Occupancy) or SMA, (Special Management Area) where no surface occupancy is allowed (see Figure 1.3-3).

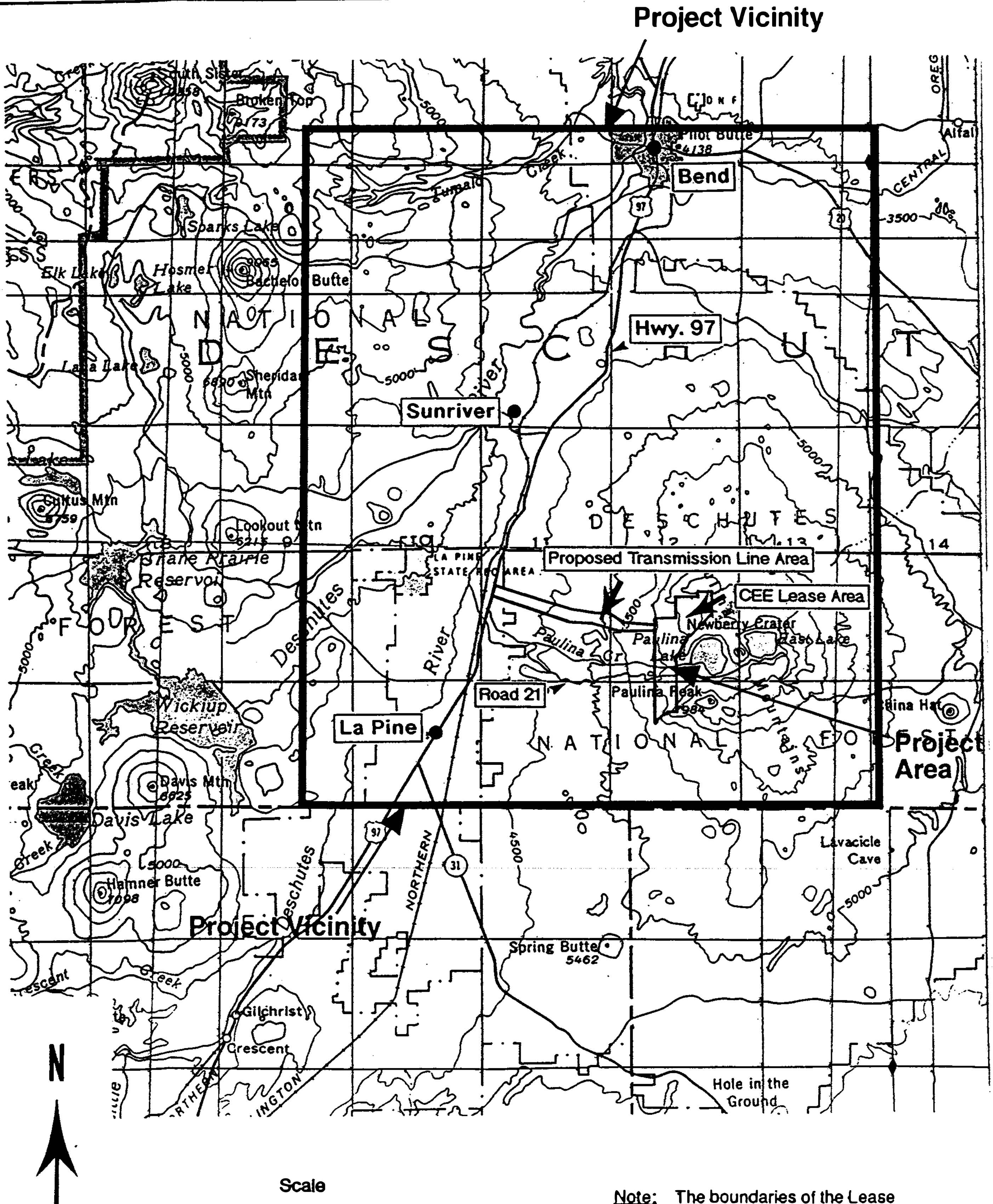
3.1.1. General Description and Overview

Newberry Volcano is a broad, gently-sloping, shield-like, forested landform that rises approximately 1,100 meters (3,600 feet) above the surrounding terrain. The proposed Newberry Geothermal Pilot Project is located on the west flank of Newberry Volcano, on Deschutes National Forest land, adjacent to (but not within) the NNVM (Figure 3.1-2). The proposed project facilities would be located on undeveloped Federal land used mainly for timber production. The western end of the project area is the lowest in elevation at approximately 1,280 meters (4,200 feet) on level terrain, just west of Highway 97 where the proposed transmission line would connect to an existing Midstate Electric line. The highest portion of the project area is in the extreme northeast corner at 2,133 meters (7,000 feet). The northeast corner of the SO lease area is currently roadless.

The range of nearly 914 meters (3,000 feet) in elevation and 9.6 km (6 miles) between the eastern and western ends of the project area accounts for differences in weather, vegetation, and wildlife. Soils and rocks in the project area and vicinity are derived from volcanic materials and are generally very permeable. Most rain and snowmelt percolates directly into the ground. There are no surface drainages, permanent waters, or wetlands within the project area. Paulina Creek, a perennial stream eligible for Wild and Scenic River status, flows between (but is not included in) the northern and southern portions of the SO lease areas (Figure 1.3-3). The SO lease area is thought to be located above a fresh groundwater aquifer separated from and underlain by a deep hydrothermal system which this proposed pilot project has been designed to utilize.

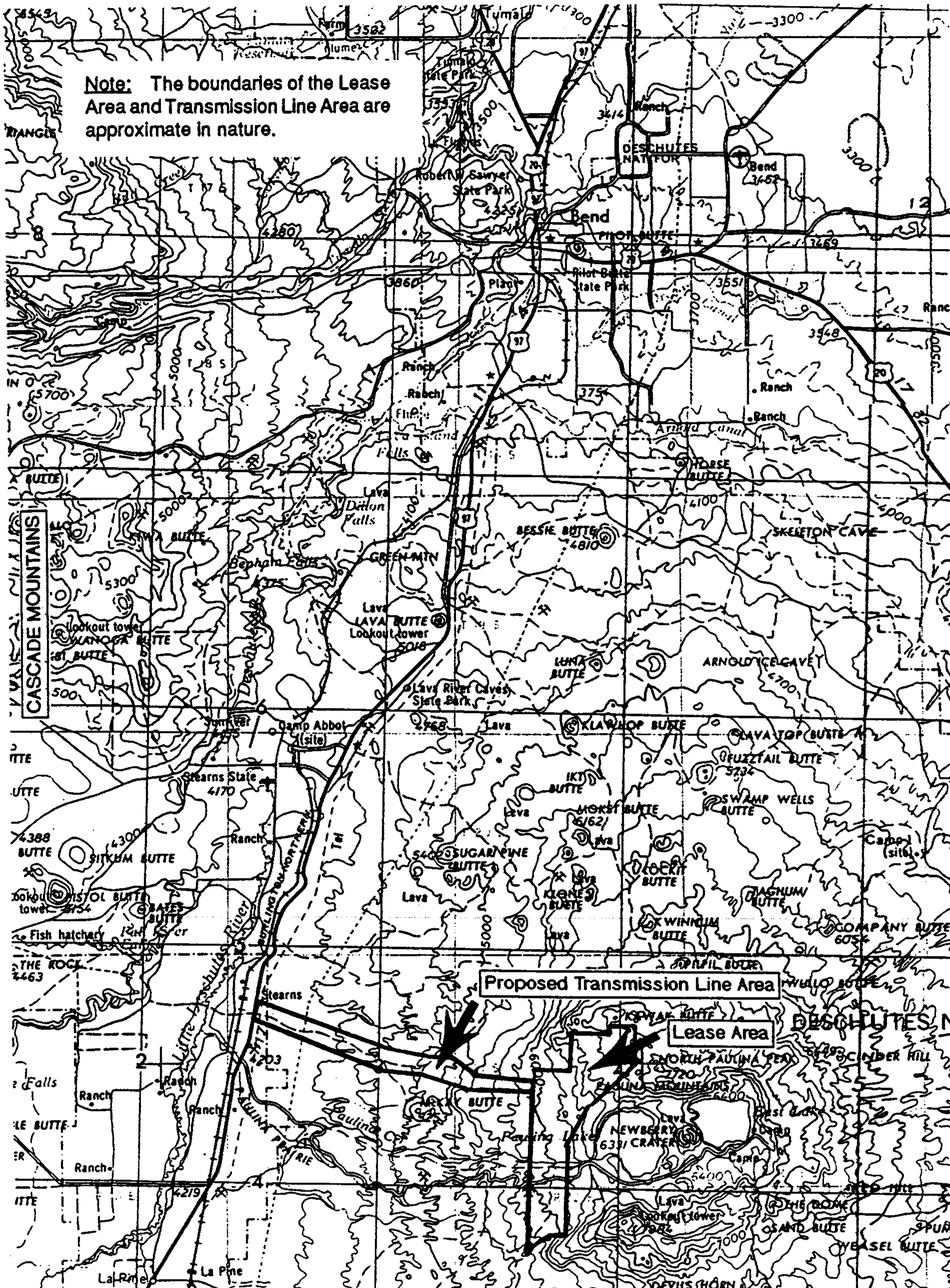
Air quality in the project vicinity is affected by wind-blown dust, pollen, and fires but is in attainment of state and Federal air quality standards. The climate is typical of the semi-arid high desert environment east of the Cascades. Precipitation comes mostly during the winter; summers tend to be warm and dry. The western end of the project area is lower, warmer, and drier than the eastern end which is comparatively higher, colder, and wetter. This difference is reflected in the vegetation. The western end of the project area is mostly ponderosa pine and lodgepole pine forest, and the eastern and higher elevation end within the SO lease area is lodgepole pine-dominated, with

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Map Showing Distinction Between Proposed Project "Area" and "Vicinity"	Figure 3.1-1



Note: The boundaries of the Lease Area and Transmission Line Area are approximate in nature.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Map Showing Topography of the Project Vicinity	Figure 3.1-2



the highest elevation areas of the NSO lease area dominated by lodgepole pine, fir, hemlock, and western white pine. The vegetation throughout the project area, particularly the areas of mature lodgepole pine, has suffered from an extended drought and insect infestations and many trees are dead. Much of the project area has been or will be harvested in the next few years. Wildlife species composition and populations are typical of those found in the pine forests of the High Lava Plains Province of central Oregon (Franklin and Dymess 1988). No threatened or endangered species of plants or animals are known to exist within the project area. Several sensitive wildlife species do occur within the project area.

The project area is visible from the top of Paulina Peak as well as other sites, including LaPine, Highway 97, and Bend. The vegetation and terrain reduce the visibility or screen some parts of the project area from these viewpoints. Ambient noise levels are relatively low. Recreational use of the project area is low but increasing nearby within the NNVM. Traffic in the project area is currently low.

There are a relatively small number of prehistoric and historic cultural resources sites within the project area; most are either scattered obsidian flakes left from tool-making or artifacts related to the historic logging railroad grade within the area. Aside from wildfires, there are no existing hazards to human health and safety in the project area. There are a few existing residences located on the extreme western end of the project area, but none of these will be the site of any proposed project facilities.

3.2. GEOLOGY AND SOILS

3.2.1. Geology

3.2.1.1. Regional Setting

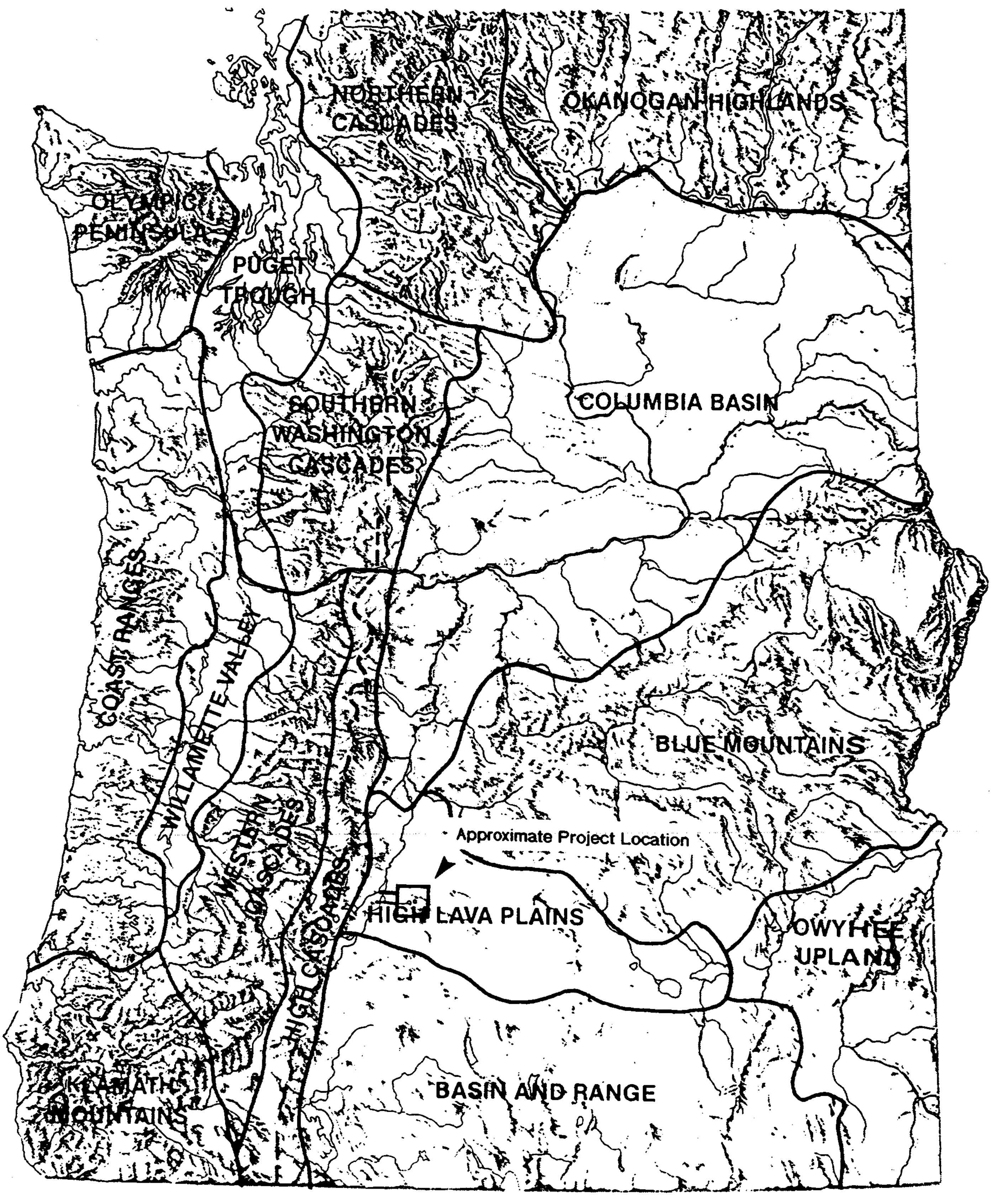
The proposed geothermal plant site is located on the west flank of Newberry Volcano which lies in the High Lava Plains Province of Oregon near the boundary with the Cascade Range Province to the west (Figure 3.2-1). The High Lava Plains Province is also bounded gradationally on the south by the Basin and Range Province. Geologically, Newberry Volcano shares tectonic and compositional characteristics with all three provinces and it is this interplay of geologic processes that has much to do with the formation of the volcano and the associated geothermal potential.

Newberry Volcano is near the intersection of three major fault systems (Figure 3.2-2). The northeast trending Walker Rim Fault Zone and the northwest trending Sisters-Tumalo Fault Zone come together at Newberry Volcano forming a broad arcuate structural zone which has offset the early Newberry lavas. Alignments of cinder cones and fissures on Newberry Volcano suggest a continuation of these systems under the volcano. The Brothers Fault Zone trends west and northwest and extends across the northeastern flank of Newberry Volcano where it apparently has not offset the Newberry lavas. These three fault systems are believed to intersect at depth. The presence of intersecting faults and silicic volcanism has created favorable conditions for high-temperature hydrothermal systems.

3.2.1.2. Newberry Volcano

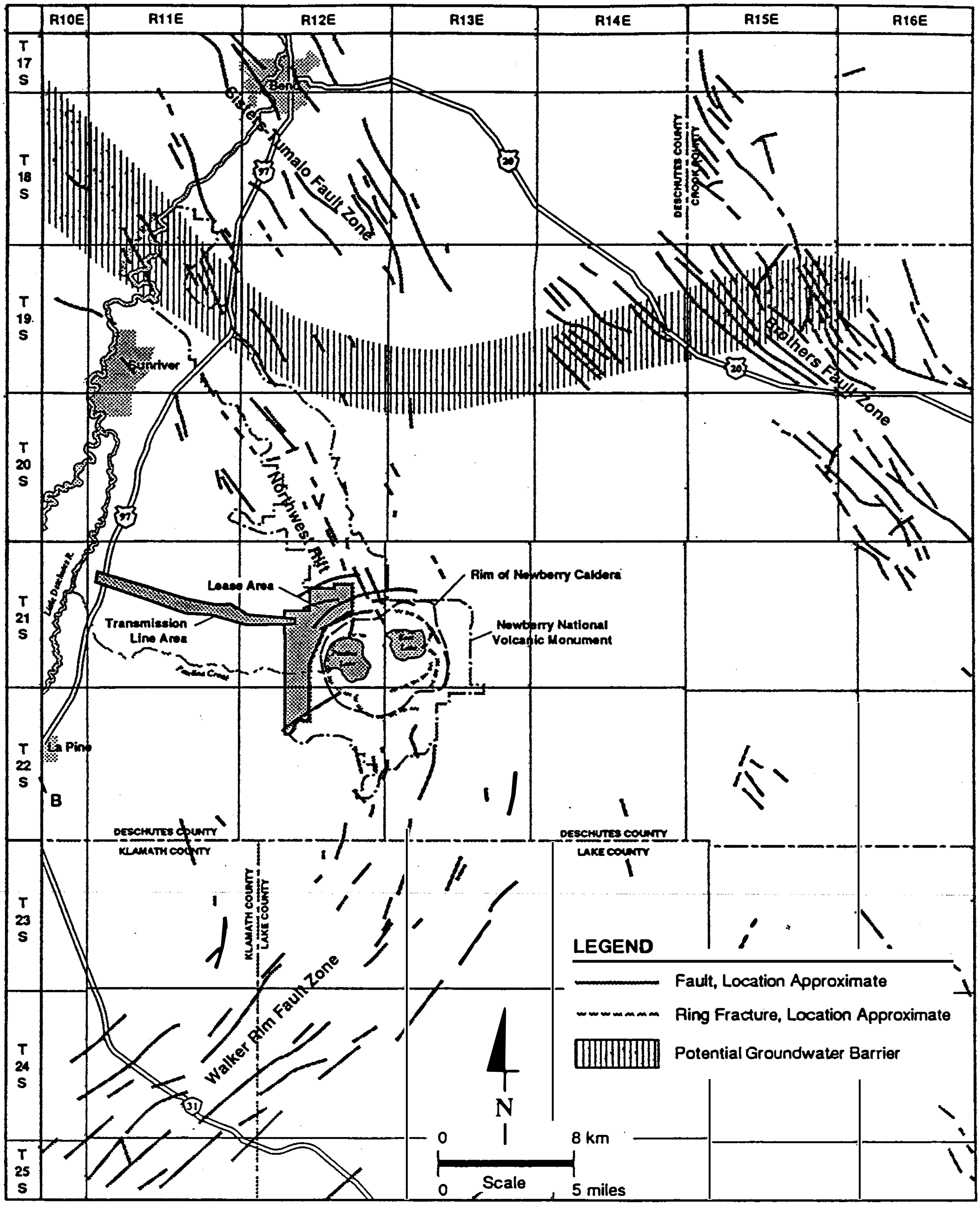
Newberry Volcano was first visited and named by Russell in 1905, and the first full study was prepared by Williams in 1935. Since the mid-1970s, Newberry Volcano has been the subject of extensive scientific investigation by earth scientists and geothermal resource explorers (Fitterman 1988 and MacLeod et al. in press).

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Physiographic and Geological Provinces of Oregon and Washington and Approximate Newberry Geothermal Project Study Area	Figure 3.2-1



Source: Franklin and Dyrness 1988

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Generalized Fault Map	Figure 3.2-2



NOTE: Geologic Structures modified from:

1. *Frink, 1968, "Groundwater Resources of the Central Deschutes Basin," U.S. Bureau of Reclamation Report.*
2. *MacLeod & Sherrod, in-press, "Geologic Map of Newberry Volcano, Deschutes, Klamath & Lake Counties, OR," USGS MGI Map.*
3. *Miller, 1986, "Groundwater Conditions in the Fort Rock Basin, Northern Lake County, OR," OWRD, Groundwater Report No. 31.*
4. *Orr, et al, 1992, "Geology o l Oregon."*
5. *Peterson, et al, 1976, "Geology and Mineral Resources of Deschutes County, OR," Oregon Dept. of Geology & Mineral Industries Bulletin 89.*
6. *Walker & MacLeod, 1991, "Geologic Map of Oregon," USGS.*

Located in central Oregon approximately 60 km (40 miles) east of the axis of the Cascade Range (Figure 3.2-1), Newberry Volcano is one of the largest volcanoes in the Cascades and has a complex eruptive history. As a topographic feature, it covers an area of 1,300 square km (500 square miles) extending 60 km (37 miles) north-south and 30 km (19 miles) east-west, with a 6- by 8-km (3.7- by 5-mile) diameter summit caldera rising to 1,100 meters (3,600 feet) above the surrounding terrain.

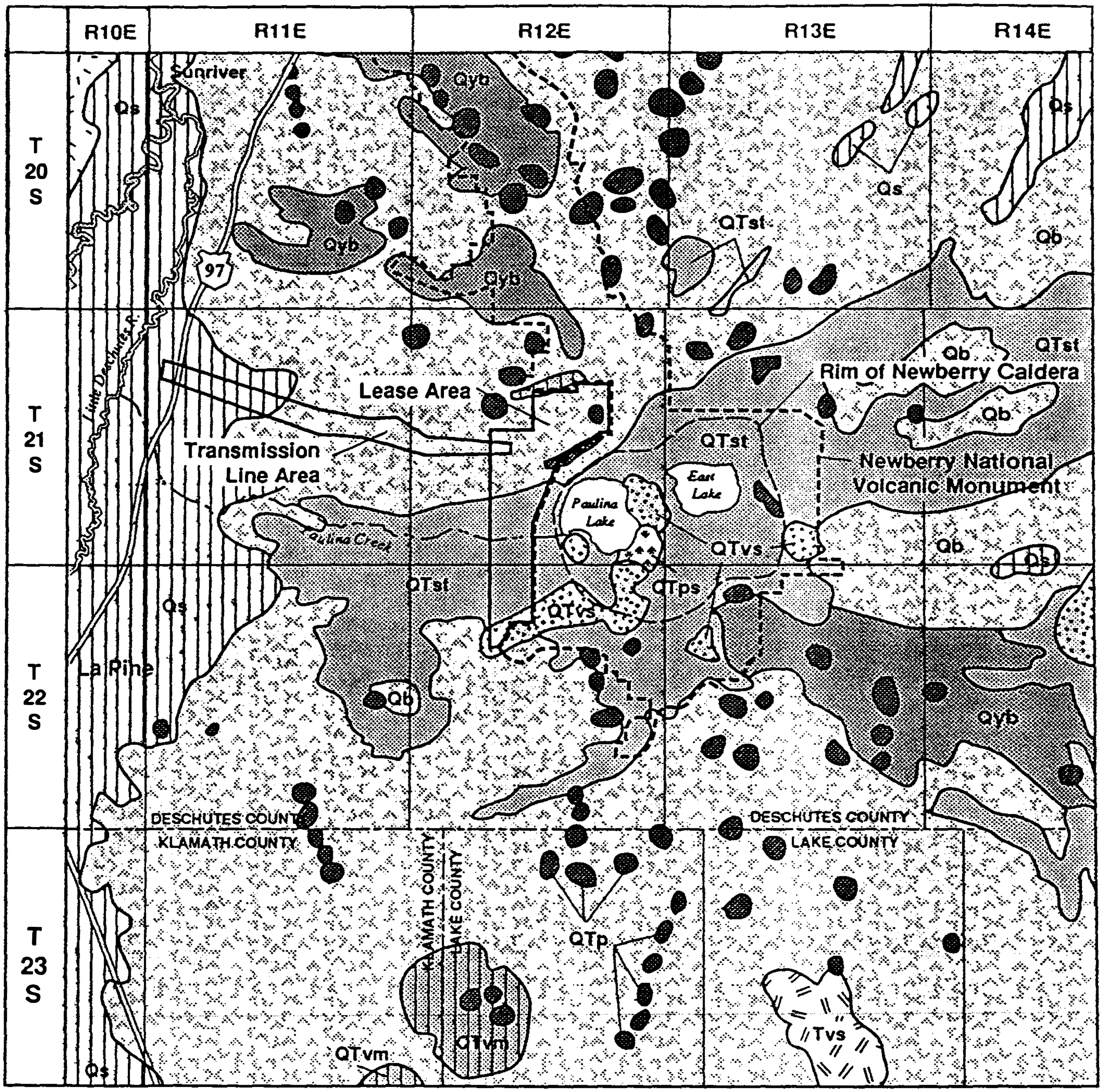
Volcanic activity at Newberry began at least 500,000 years ago (Feibelkorn et al. 1983). Its flanks, which are covered with more than 400 cinder cones and fissure vents, are composed of volcanic rocks from lava flow, ash flow, and air-fall eruption and from sediments accumulated from erosional processes. The numerous flows overlap and vary considerably in thickness and in lateral extent. The generalized geology of the area is shown in Figure 3.2-3. Newberry Volcano has erupted at least 25 times in the past 10,000 years, most recently 1,350 years ago when the Big Obsidian Flow erupted. Numerous recent silica-rich ("silicic") domes, breccias, and flows are present within Newberry Caldera. Those less than 6,700 years old are all chemically similar (MacLeod and Sherrod 1992).

It appears likely that a small shallow magma chamber is present, providing a continuing source of heat to the hydrothermal system beneath the volcano as shown in Figure 3.2-4. Large volumes of young silica-rich volcanics, high geothermal gradients (MacLeod and Sherrod 1988), and seismic survey evidence (Achauer and Evans 1988) indicate that a magma chamber of a few to a few tens of cubic km in volume is present beneath Newberry Caldera at a depth of about 3 km (2 miles) (MacLeod and Sammel 1982). However, other studies do not confirm the presence of this shallow magma body. Catchings and Mooney (1988) conducted a deep seismic refraction survey across Newberry Volcano and reported the absence of a low seismic velocity zone that would indicate the presence of a magma chamber. They concluded that a large magma chamber does not exist in the upper crust at Newberry Volcano, at least along their line of measurements. They noted that the weakening of the seismic signals they observed may be consistent with either small partially-melted magma chambers or other phenomena. One possible model that is consistent with these conflicting observations was proposed by Linneman (1990), who suggested that Newberry Volcano was formed by repeated small-volume mafic (iron-magnesium rich) magma injections into the crust from very deep magma chambers beneath the earth's crust, followed by partial melting of the upper crust, generating the bimodal (basalt/rhyolite) volcanic style that distinguishes Newberry Volcano.

Newberry Volcano is in a period of quiescence (little or no volcanic activity) since the last eruption 1,350 years ago. This also suggests the probability of future volcanic activity (Fitterman 1988). Seismic studies at Mount St. Helens (Lees 1992) and ground deformation studies at four active volcanoes (DeNatale and Pingue 1993) indicate that shallow magma chambers are commonly accompanied by ground deformation and seismic activity, which have not been reported at Newberry. The geologic cores recovered from the USGS Newberry 2 drill hole show that in the past, periods of quiescence have lasted for 2,000 to 3,000 years (MacLeod and Sherrod 1988).

The summit of Newberry Volcano is distinctive in its steep-walled, basin-like form. It is interpreted by geologists as a volcanic caldera. Calderas form when a volcanic edifice collapses into its magma chamber, usually accompanied by a voluminous pumice eruption. Several sets of semicircular "ring" fractures encompass Newberry's summit, suggesting that caldera collapse took place in several stages (MacLeod and Sammel 1982). At least two episodes of large pumice eruptions have been identified that are large enough to be the products of caldera collapse (MacLeod and Sherrod 1992). The earliest collapse event occurred approximately 500,000 years before present and the latest collapse event approximately 200,000 years before present. The present caldera is interpreted as several nested calderas of different ages, the result of sequential collapse totaling 500 to 800 meters (1,640 to 2,625 feet). Subsequent volcanic and sedimentary processes have filled the caldera with approximately 490 meters (1,600 feet) of deposits.

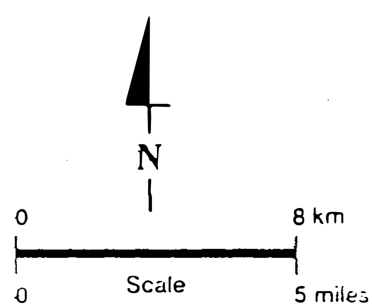
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Generalized Geologic Map	Figure 3.2-3



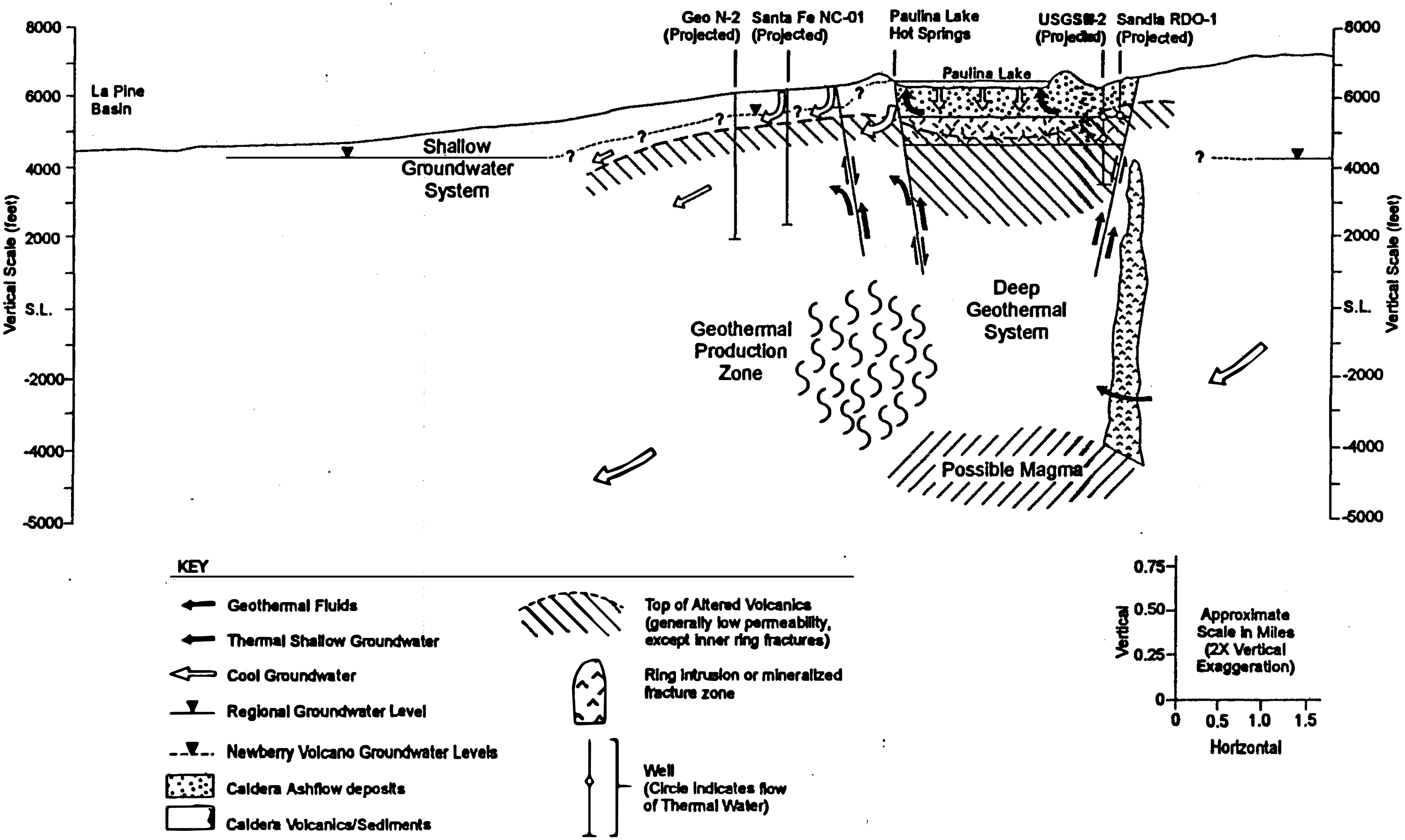
NOTES:
1. Contacts between geologic units are approximate.
2. Geology modified from Walker & MacLeod, 1991, Geologic Map of Oregon, USGS.

LEGEND

- **Qyb** Youngest Basalt & Basaltic Andesite *(Holocene)*
- **Qs** Lacustrine & Fluvial Sedimentary Rocks *(Pleistocene)*
- **Qb** Basalt & Basaltic Andesite *(Holocene & Pleistocene)*
- **QTp** Basaltic & Andesitic Ejecta *(Holocene & Pleistocene)*
- **QTps** Subaqueous Basalt & Andesitic Ejecta *(Holocene & Pleistocene)*
- **QTvs** Silicic Vent Deposits *(Holocene & Pleistocene)*
- **QTvm** Mafic Vent Deposits *(Pleistocene & Pliocene)*
- **QTst** Tuffaceous Sedimentary Rocks & Tuffs *(Holocene & Pleistocene)*
- **QTba** Basalt & Basaltic Andesite *(Pleistocene & Pliocene)*
- **Tvs** Silicic Vent Rocks *(Pliocene)*



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Geologic Cross-Section Schematic Flow of Cold and Thermal Waters	Figure 3.2-4



Drilling in Newberry Caldera has been described by Keith and Bargar (1988) for the USGS Newberry 2 drill hole and by Keith et al. (1986) for Sandia Labs RDO-1 drill hole. Both wells were located near the toe of the Big Obsidian Flow. The drill cores from Newberry 2 reveal two episodes of silicic volcanism separated by a group of basaltic andesite eruptions. Also, well-sorted sedimentary rocks between 305 and 325 meters (1,000 to 1,065 feet) suggest that a single large caldera lake existed in the past. The Newberry 2 drill hole was drilled to a depth of 932 meters (3058 feet) and the RDO-1 hole to 424 meters (1391 feet). From the top down, both drill holes penetrated about 110 meters (360 feet) of silicic volcanic ash and obsidian, 200 meters (650 feet) of basaltic tuff (compacted volcanic fragments), 20 meters (65 feet) of lake sediments, and about 100 meters (300 feet) of hard silicic ash (lithic tuff). Newberry 2 was drilled below this depth through another 250 meters (820 feet) of silicic volcanic rock underlain by 240 meters (790 feet) of basaltic andesite lava flows.

Rock type changes abruptly from mainly fragmental and air-fall volcanics (e.g., ash, pumice, tuff) to volcanic flow rocks (e.g., obsidian, rhyolite, dacite) below 500 meters (1,650 feet) and to another lithologic change of basaltic andesite flow rocks below about 700 meters (2,200 feet). The beginning of caldera formation and the precaldera surface could be represented by the change from flow- to air-fall volcanic styles at 500-meter depth, or alternatively to the change from basaltic andesite to silicic eruptions at 700 meters. Below the precaldera surface, the volcanic sequence may be similar to that encountered in the project area.

Ring fractures around the caldera rim may extend vertically into the earth, or they may dip at a fairly steep angle. Dip angle is of interest, because geothermal drilling will target the ring fractures as likely pathways connecting to a geothermal reservoir. Many published caldera cross-sections show ring fractures dipping toward the center of the caldera, although geologic evidence is limited about the direction that ring fractures dip. Some recent experimental studies (Komuro 1987) and seismic evidence from the actively subsiding Rabaul caldera in New Guinea (Mori and McKee 1987) suggest that collapse-caldera ring fractures form in response to magma withdrawal and that the mechanics of rock failure cause ring fractures to dip outward from the volcanic summit at steep dip angles.

At the time they are formed during caldera collapse, ring fractures probably extend from the surface down to the magma chamber, providing pathways for magma toward the surface. Dikes (cooled magma in fractures) may later seal the ring fractures. Geophysical studies indicate the possible presence of dikes or highly mineralized fractures. The intruded/mineralized zone extends upward to an elevation of approximately 1,300 feet and is open to the west.

As the caldera settles and adjusts over time, seismic activity may fracture the dikes, resulting in relatively high permeability (open connected spaces) along the ring fracture system, providing a pathway for geothermal fluids to circulate. The Newberry ring fractures cut across the dense, massive basaltic andesite lava flows that have been observed in core holes. These lava flows appear to have almost no vertical permeability (Keith and Bargar 1988). Thus, ring fractures (and other geologic faults, fractures, and volcanic vents that may be present at Newberry Volcano) provide the most likely vertical pathways for circulation of hydrothermal fluids (Sammel et al. 1988).

Numerous valued volcanic features are located on Newberry Volcano and the surrounding area, including the Lava Butte Cinder Cone, the Lava Cast Forest, the Lava River Cave, and the Newberry Caldera. In 1990, the U.S. Congress established the Newberry National Volcanic Monument as part of the National Forest System to preserve these unique features. The Monument and special designated areas comprise 24,119 hectares (59,600 acres) of the Newberry Volcano.

Additional geologic information is given under Section 3.4 Geothermal Resources.

3.2.1.3. Project Area Geology

The upper western flank of Newberry Volcano consists primarily of late Quaternary ash-flow deposits (mostly non-welded), basaltic lava flows, and cinder cones and ridges. The ash-flow deposits occur south of an unnamed cinder cone in section 28, T. 21 S., R. 12 E., and the lava and cinders occur to the north. The lava flows are variously rubbly, blocky, and dense, and are not significantly eroded. Cohesionless, uncompacted, easily excavated, windblown soil and Mazama ash fill the low areas in these flows. Permeability of the soils and lava is high. Even during high intensity storms or rapidly melting snow, surface water infiltrates soils and lava at such a rapid rate that no flowing or standing surface water has ever been reported anywhere on the upper flanks of Newberry Volcano (except for Paulina Creek).

The ash-flow deposits, which occur both north and south of Paulina Creek, consist mostly of cohesionless, somewhat compacted, easily excavated ash and lapilli sizes (sand and gravel sized grains). In the lower elevations of the project area, the ash-flow deposits have been eroded in a series of shallow, parallel, west-draining valleys several tens of feet deep. Soils overlying the ash-flow deposits thicken and thin depending on their position on valley ridges, slopes, and floors. The soils consist of reworked ash-flow deposits and Mazama ash, and, like those among the lava flows, are cohesionless, uncompacted, easily excavated, and highly permeable.

Slopes in areas of proposed facilities are mostly gentle (7 to 11 percent). Potential for mass movement within the project area is very low. No evidence exists of surface faulting or landslide events. However, faulting in the subsurface is highly probably based on projections of faults in the Walker Rim and Tumalo-Sisters fault systems.

3.2.2. Soils

Soils development is based on parent material, climate, organisms, topography and time. Soils in the project vicinity are primarily created and influenced by volcanic eruptions and are characteristically coarse-textured, light-colored, excessively drained, and have low bulk densities. Typically, the soils are rich in potassium, calcium, and magnesium content but are poor in nitrogen, phosphorus, and sulfur content. The soils exhibit low thermal conductivity and can experience wide ranging daily fluctuations in surface temperature which can contribute to frost heaving when soils are moist or saturated.

Soils at Newberry are derived primarily from the eruption of Mount Mazama (Crater Lake, about 7,600 years ago). The pumice and ash mantle ranges from 50 to 100 cm (20 to 40 inches) and supports forested areas. Other soils derived from pumice, ash and cinders underlie, overlie, and are mixed with the Mazama ash soils. Scattered thicker deposits typically consist of materials that have been redeposited after eroding from upslope positions. In addition, there are numerous deposits of volcanic ejecta near cinder cones.

Surface soils in the project area are typically dark brown to yellowish brown, sandy, and consist of pumice ash and small glassy fragments (lapilli). These are underlain by older brown-sandy to loamy soils. Surface and subsurface soils may include gravel, cobbles and stones. Depth to bedrock, where bedrock is basalt and andesite, is from 76 to 113 cm (30 to 45 inches). The soils are slightly acid to neutral. See Appendix K for more detailed soil and land type information for the project area.

Soil erosion in the project area occurs primarily from wind and as soil creep, sheet erosion, and dry ravel; erosion potential is considered to be low to moderate. Erosion and dustiness are common on unsurfaced roads. Surface runoff seldom occurs for more than a short distance due to the rapid infiltration into the soil. Surface layers of the coarse-textured pumice soils are easily displaced by mechanical activity. Soil compaction occurs with heavy activity and with displacement of the surface soils. Soils beneath nearly all of the project area and the transmission routes are mapped as having low susceptibility to compaction. Mass failures are rare except in a few higher elevation areas.

3.2.3. Geologic Hazards and Risks

3.2.3.1. Seismicity

Seismicity is attributed to fault movement and magmatic activity. The project area is located near major faults, and could potentially be affected by renewed movement or activity of these features. However, from a historical standpoint, central Oregon — including the project area — is considered to be of low risk for serious damage from seismic activity. Seismic risk and earthquake intensity maps (Ben-chieh Liu et al. 1981) indicate this region of Oregon has experienced only a few minor earthquakes and should one occur, only minor damage would be expected. The vicinity of Newberry Volcano is located in Seismic Zone 2B.

No surface faults or signs of ground rupture are known to exist within the project area. Buried faults are suspected beneath the project area based on the projection of the nearby fault zones. The most recent faulting and ground rupturing occurred approximately 6,700 years ago along the Northwest Rift zone of Newberry Volcano.

3.2.3.2. Liquefaction

The soils in the region are coarse, well drained, rarely saturated, and not considered to be susceptible to liquefaction.

3.2.3.3. Volcanism

The area is characterized by geologically recent silicic and mafic volcanism. Volcanic activity began in the region at least 500,000 years ago and is very likely to continue into the future. During the past 12,000 years, eruptions have occurred at more than 25 sites within the project vicinity; the most recent was about 1,300 years ago. Dormant periods between eruptions are generally 2,000 to 3,000 years. The life of this project is quite small compared to the expected length of dormant periods.

3.2.3.4. Subsidence

Localized subsidence in the project area is unlikely due to the competent nature of the bedrock. General subsidence around the volcano has occurred in the past as evidenced by caldera development and associated ring fractures. Caldera subsidence is related to large magma chambers and major volcanic activity. Recent geophysical studies have demonstrated that no large magma chambers currently exist under Newberry Volcano. Renewed movement along existing fault planes or general subsidence can occur where large volumes of formation fluids are removed causing changes in formation pressure. Subsidence is covered in the environmental baseline requirements of the GRO Orders.

3.2.3.5. Slope Stability/Landslides

The project area shows no signs of recent ground rupture or displacement. Slopes in the region are generally quite gentle and considered to be stable.

3.2.3.6. Frost Action

Frost action in different forms can result when water in soil freezes. Ice lenses can render the soil impervious, and growing ice crystals can lift soil vertically upwards 30 cm (1 ft) or more. Frost action is greatly enhanced where surface organic material (duff) is removed. The soils in such areas become highly susceptible to movement and flow when they become saturated above ice lenses. Frost heave impairs plant establishment and growth.

In the project area, frost action is limited and confined to the growth of needle ice in the upper few inches of bare soil. During thaw, the collapse of the needle ice enhances surface soil creep and does not present a risk to either structures or sumps.

3.2.4. Mineral Resources

The geothermal resource at Newberry Volcano appears to be the only significant mineral resource in the project area. There are no known commercial deposits of precious, strategic, or base metals in the project region. However, cinders and lava continue to be quarried from the flanks of Newberry Volcano for use as road construction material.

3.3. WATER RESOURCES

The study area for this section is defined as an area 64 km (40 miles) wide (east/west) by 80 km (50 miles) long (north/south), and it includes portions of Deschutes, Crook, Lake, and Klamath Counties.

In 1991, the USGS began a baseline hydrologic and water-quality data collection program for BPA, BLM, and the U.S. Forest Service in order to help identify and assess the potential impacts of proposed geothermal development (Morgan 1991a, 1991b, and 1992). Types of data collected include groundwater levels, lake levels, streamflow, water quality, and meteorological measurements. Data were collected from June 1991 through September 1993. If development were to be approved, long-term monitoring would continue in order to detect physical and chemical changes in the hydrologic system in Newberry Caldera that could be caused by exploration, development, or utilization of geothermal resources.

The following description is primarily based on a recent report written by Dames & Moore (1994). The 1994 Dames & Moore report includes a review of all published water resources and water quality data. A primary source was the STORET data management system administered by EPA and the Oregon Department of Environmental Quality (DEQ). Data obtained by a number of state and Federal agencies are stored in the STORET system. The agencies include DEQ, EPA, Oregon Department of Water Resources (WRD), U.S. Forest Service, USGS, and the U.S. Bureau of Reclamation. STORET has data on Paulina Creek, Little Deschutes River, Deschutes River, Tumalo Creek, Paulina Lake, East Lake, Wickiup Reservoir, and water wells in the following areas: Newberry Crater, LaPine subbasin, Deschutes River watershed, and Tumalo Creek watershed.

Published data contained in past USGS hydrologic studies of Newberry Caldera were also reviewed (Ingebritsen 1986; Phillips 1968; Sammel 1983; Sammel 1988). The USGS Newberry Caldera data includes information on Paulina Lake, East Lake, caldera groundwater, Paulina Lake thermal springs, East Lake thermal springs, caldera geothermal steam, and Paulina Creek.

3.3.1. Studies Performed

Two studies have been performed to characterize the hydrology in the vicinity of Newberry Volcano. The first study — begun in 1991 by the USGS at the request of BPA, BLM, and the U.S. Forest Service — collected hydrologic, water-quality, and meteorologic data at approximately 21 sites (sampling points were added and dropped as the study progressed). The purpose of the study was to provide baseline data for identifying and assessing impacts of geothermal development. The study was limited to data collection, which is ongoing, with only limited interpretation of the data. Data collected will be published in a USGS open-file report in mid-1994 (Crumrine and Morgan 1994). The monitoring program is summarized below.

A second study was done by Dames & Moore of Portland, Oregon, in 1993. This study collected and interpreted available hydrogeologic data for the Newberry area, but generated no new data. A Hydrology Baseline Report was prepared, which included:

- A compilation of existing data
- Collation of pertinent publicly available data interpretations
- Results of field review and ground truthing of existing data
- Identification of key environmental issues
- Tables and maps of reviewed geological and hydrological information
- Data analysis and interpretation, including both existing and potential for interaction between the cold groundwater and geothermal systems resulting from geothermal development, and the potential impact of interaction on environmental issues

3.3.2. Geological Survey Hydrologic Monitoring Program

After performing a literature search and other preliminary investigations, the USGS initially selected 17 monitoring sites. These were later expanded to 21 sites, listed in Table 3.3-1. These sites include: (1) 12 wells, (2) two piezometers in hot springs areas, (3) lake gauges on East and Paulina Lakes, (4) water-quality vertical profiles and water-quality sampling sites on the lakes, (5) a streamflow data site on Paulina Creek, and (6) a streamflow measurement and sampling site on Paulina Creek 13 km (8 miles) downstream from the lake. The locations of monitoring sites within Newberry Caldera are shown in Figure 3.3-1.

Data collection was based on the "Guidelines for Acquiring Environmental Baseline Data on Federal Geothermal Leases" and USGS recommendations. Over 50 water quality parameters were measured, including water temperature, pH, specific conductance, dissolved oxygen, common anions and cations, nutrients, trace elements, radio-chemicals, and isotopes. These parameters are listed in Table 3.3-1. Meteorological data were also collected, including wind velocity, air temperature, humidity, solar radiation, and precipitation.

If the proposed geothermal project were to be approved, hydrologic monitoring would continue.

3.3.3. Regional Hydrology

The project vicinity falls within two major watersheds, the Deschutes Basin and the Fort Rock Basin (Figure 3.3-2). A watershed is generally defined as the area which receives surface runoff from snow and rain and drains to a particular watercourse. The Deschutes River and a major tributary, the Little Deschutes River, drain the Deschutes Basin and flow to the Columbia River, 225 km (140 miles) to the north. Therefore, the Little Deschutes River is within the Deschutes River watershed, and the Deschutes River is within the Columbia River watershed. There are no major surface streams and no surface outlet in the Fort Rock Basin. The Fort Rock Basin is a closed watershed.

Soils and rocks in both the Deschutes and Fort Rock basins are very permeable, and most rain or snowmelt percolates directly into the ground. Groundwater in the upper Deschutes Basin, south of Bend, moves primarily northward within permeable volcanic rocks and unconsolidated silt, sand, and gravel deposited during the past 2 million years. It is estimated that about 135 million cubic meters (1.1 million acre-feet) of water recharges the upper Deschutes Basin groundwater basin annually, coming primarily from the eastern slope of the Cascade Range (King 1991). The Deschutes Formation north of Bend is the principal aquifer in the Deschutes Basin, although groundwater also occurs in other smaller geologic units. These units are being evaluated in a current USGS study. Groundwater flow in the region is generally toward the north.

Table 3.3-1 Newberry Hydrologic Monitoring Sites and Sampling Program - 1994

Monitoring Site Name	Location	Monitoring Frequency[1]			
		Chemistry[3]	Stage/ Water Level	Temperature/ Conductance	Climate[2]
Hot Springs					
East Lake Hot Spring (P-4)	21S/13E-29cdd2	S	S	S	
Paulina Lake Hot Springs	21S/12E-26aab1	S	S	S	
Wells					
Cinder Hill CG No. 7	21S/13E-29aac		SM,I	SM,I	
Geo-Newberry	21S/13E-29dca1	A	SM,I	SM,I	
Hot Springs CG No. 1	21S/13E-32abb	A	SM,I	A	
East Lake CG No. 1	21S/13E-32bbb		SM,I	SM,I	
Sandia	21S/13E-31cdb	S	C	S	
Little Crater CG No. 3	21S/12E-36baa	S	C	S	
Newberry Group Site CG	21S/12E-35dcb	A	SM,I	A	
Paulina Guard Station	21S/12e-34acc	A	SM,I	A	
Paulina Lake Lodge No. 1	21S/12E-34acb1	A	SM,I	A	
LaPine High School	22S/10E-10da	B	I	B	
China Hat Guard Station	22S/14E-22bbc	B	I	B	
Prairie Campground	21S/11E-28cba	B	I	B	
Streams					
Paulina Cr. nr outlet	21S/12E-34acb	S	C	C	
Paulina Cr. nr bridge	21S/11E-28bca	S	S,I	S,I	
Lakes					
Paulina Lake	PL-11-30	S		S	
	PL-11-60	S		S	
East Lake	EL-08-30	S		S	
	EL-08-60	S		S	
Other					
Paulina Lake Weather Station	21S/12E-34acb				C

[1]Explanation of frequency codes:

A	Annually
B	Biannually
C	Continuously
I	Intermittently
M	Monthly
Q	Quarterly
SM	Semimonthly
S	Semiannually

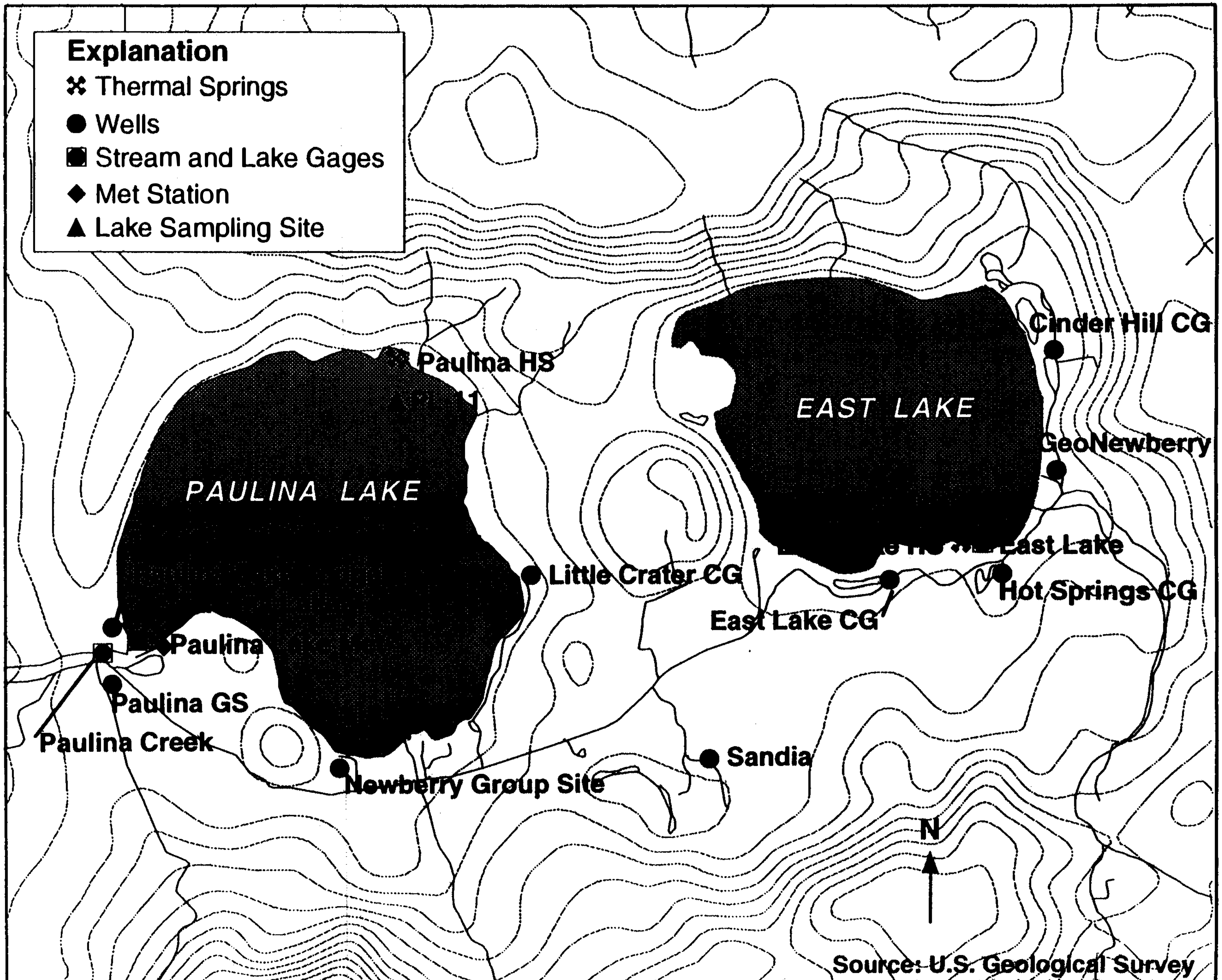
[2]Climate data includes:

Wind speed
Relative humidity
Precipitation
Solar radiation
Temperature

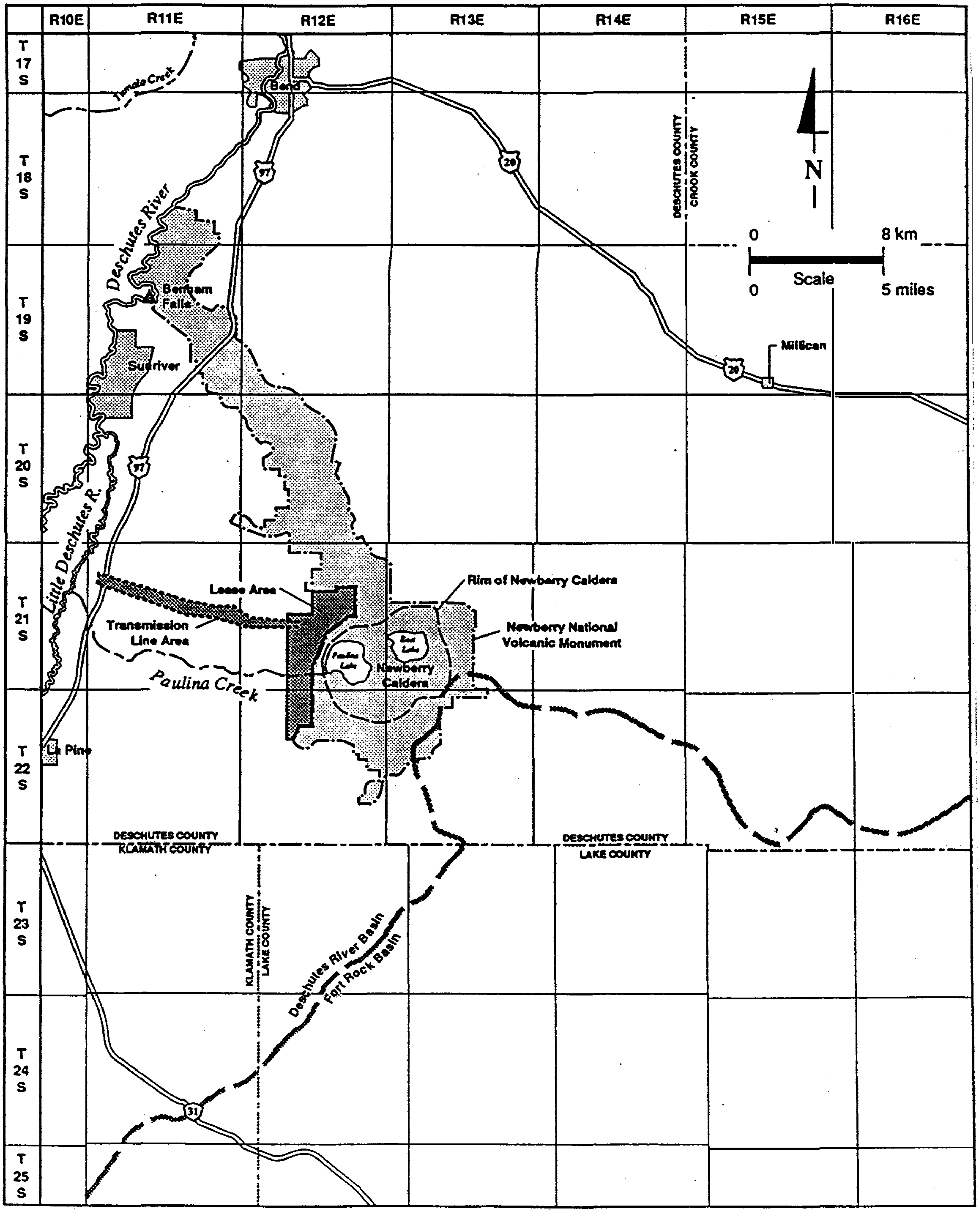
[3]Chemical analyses include:

Temperature	Mercury
Specific conductance	Iron
pH	Manganese
Alkalinity	Dissolved solids
Dissolved oxygen	Oxygen 18/16 ratio
Chloride	Deuterium/hydrogen ratio
Fluoride	Lithium
Nitrite-Nitrate	Arsenic
Phosphorous	Boron
Sulfate	Silica
Ammonia	Potassium
Calcium	Sodium
Magnesium	Strontium
Barium	Zinc

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Newberry Crater Hydrologic Monitoring Sites	Figure 3.3-1



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Watershed Boundary within the Project Vicinity	Figure 3.3-2



3.3.4. Hydrology of Newberry Volcano

Newberry Volcano caldera rim is located near the boundary of the Deschutes and Fort Rock Basins. The northeast, northwest, and southwest sides of the volcano (and its caldera) slope toward the Deschutes River. The southeast side of the volcano slopes toward the Fort Rock Basin. About 90 cm (35 inches) of precipitation fall on the caldera annually, much of it in the form of snow (Sammel 1983; Phillips 1968). This is considerably higher than precipitation amounts in adjacent areas, roughly three times that falling at the City of Bend, located 40 km (25 miles) to the northeast.

3.3.4.1. Surface Water

Newberry Volcano has three primary surface water features: East Lake, Paulina Lake, and Paulina Creek, which drains Paulina Lake. Paulina Lake and East Lake lie within the caldera. Paulina Creek drains into the Little Deschutes River and is the only surface water outlet for the caldera. There are no other perennial surface streams on the Newberry Volcano, and no reported intermittent streams.

East Lake is approximately 55 meters (180 feet) deep and covers approximately 4.1 square km (1,000 acres). East Lake is 12 to 15 meters (40 or 50 feet) higher than Paulina Lake; groundwater appears to flow from East Lake to Paulina Lake. There is no surface outlet for waters draining East Lake. However, water levels remain relatively constant, varying by about 4.9 meters (16 feet), suggesting that inflow (runoff) and outflow (evaporation/groundwater recharge) tend to balance one another (Phillips 1968; Dames & Moore 1994).

The elevation of Paulina Lake's water surface is controlled by a dam at its outlet to Paulina Creek. Paulina Lake levels have been manipulated since 1899. It has an area of 6.1 square km (1,500 acres) and is approximately 76.2 meters (250 feet) deep. Sammel (1983) estimated the lake outflow (Paulina Creek discharge) to be about 16 million cubic meters (13,000 acre-feet) per year.

Average precipitation in the caldera totals about 39 million cubic meters (31,900 acre-feet) per year, most of which infiltrates into the ground. Loss of water through evaporation from lakes, surface water, and vegetation and average annual flow from the caldera through Paulina Creek is estimated at 80 percent of total average precipitation. The total annual discharge of Paulina Creek near LaPine (from October 1991 to September 1992) was 11,744,100 cubic meters (9,520 acre-feet). Between 3,085,000 to 8,020,000 cubic meters (2,500 and 6,500 acre-feet) per year is estimated to percolate into the regional groundwater reservoir from the caldera (Sammel 1983).

The quality of water in the two lakes appears to be fairly stable during the year. Both lakes contain water with low concentrations of dissolved substances. East Lake waters have a total dissolved solids content of about 200mg/l. Nutrient and chloride levels are very low in both lakes and heavy metals concentrations are below the detection limit of USGS analytical tests. Both lakes exhibit temperature stratification at most of the periods and stations sampled. Dissolved oxygen content is generally high, except near the lake bottom. (Crumrine and Morgan 1994).

Well and spring water quality in the caldera is quite variable, although water quality is generally similar to that of the lakes. Some wells contain waters with a very low dissolved solids content, less that 100mg/l. Others exhibit total dissolved solids contents of about 800mg/l, about twice the highest level measured in Paulina Lake.

3.3.4.2. Groundwater

Groundwater flow in the shallow aquifer within the project vicinity generally conforms to the surface watersheds. Dames & Moore estimated that 553,000,000 cubic meters (448,000 acre-feet) per year of water percolates into the ground on the flanks of Newberry Volcano and that half of it flows into the upper Deschutes Basin. This represents about 20 percent of the estimated quantity of water flowing through the basin. As noted above, 3,085,000 to 8,020,000 cubic meters (2,500 to 6,500 acre-feet) per year are estimated to recharge into the regional groundwater from the caldera itself.

The movement of groundwater in the shallow aquifer system at Newberry Volcano is complex and only partially understood. The volcano's flanks are underlain by complexly interbedded lava flows and sediments. Most subhorizontal groundwater flow is probably along the rubble zones at the top and bottom of each flow. Subvertical flow probably occurs between rubble zones where the zones overlap or are cut by fractures. Temperature measurements in boreholes on the west flank indicate that isothermal conditions exist above depths of 600 meters (2,000 feet). These conditions are interpreted to indicate the maximum depth of fresh water circulation in the shallow aquifers. The lower boundary of the aquifer system is believed to represent a major decrease in permeability (Blackwell, 1993) as shown in Figure 3.2-4. Groundwater flow within the caldera is complex and poorly understood. Precipitation inflitrating the permeable soils percolates to a shallow water table at depths of 6 to 15 meters (20 to 50 feet) below ground surface, which probably slopes inward toward the lakes. Under the influence of the water table, shallow groundwater flows laterally toward the lakes into which it discharges. The surface of East Lake is about 13.7 meters (45 feet) higher than that of Lake Paulina, and groundwater must flow westward from East Lake to Lake Paulina and then outward through the breach in the caldera wall through which Paulina Creek flows (Dames & Moore, 1994).

Deeper groundwater flow within the caldera is controlled by the subvertical ring fractures and subhorizontal rock layers as shown in Figure 3.2-4. As noted by Macleod and Sammel in 1982, vertical permeability in the caldera fill and in the collapsed caldera block is low, and any vertical connection would be limited to faults, ring fractures, and brecciated intrusion contacts. Horizontal flow would be limited to permeable zones (rubble zones) with good hydrological connections to water-bearing fractures. These water-bearing zones are likely to be perched above the regional water table. In the deep Newberry 2 test hole, cold water perched aquifers were encountered at depths of 273 meters (896 feet) and 541 meters (1,776 feet), and warm water aquifers were encountered at depths of 341 meters (1,120 feet) and 439 meters (1,440 feet) (Fig. 3.4-3). Below 739 meters (2,425 feet), few permeable zones were encountered.

3.3.4.3. Hot Springs and Geothermal Fluids in Newberry Caldera

There are two distinct components of the hydrothermal system at Newberry Caldera: a shallow hydrothermal system consisting of hot springs and a deep geothermal system consisting of geothermal resources at higher temperatures and depths greater than 396 meters (1,300 feet) below ground surface (Dames & Moore 1994). The high-temperature deeper fluids are described in Section 3.4, Geothermal Resources.

The thermal springs within the caldera are located along Paulina Lake's northwest shore and East Lake's southeast shore. The springs extend from the shoreline a short distance beneath the lake, where their locations are marked by rising columns of CO_2 bubbles. On land, cemented sand deposits along Lake Paulina and altered volcanic rock along East Lake indicate that thermal activity once occurred at higher elevations. The springs are considered to be fumeroles (gas vents) covered by the lakes (Mariner and others 1980). The presence of only steam in the bottom of the deep test hole, Newberry 2, is consistent with this hypothesis.

The degree of direct connection between the shallow and deep hydrothermal systems is probably slight. The Newberry 2 test hole encountered low permeability, hydrothermally altered rock at depths below 213 meters (700 feet) and dense lava flows below 700 meters (2,300 feet)as shown in Figure 3.2-4. Below approximately 700 meters (2,300 feet), the temperature curve in Newberry 2 becomes conductive or linear with depth (Figure 3.4-3), which indicates that most of the permeability in the lower part of the hole has been lost. Additional supporting evidence comes from a comparison of fluid chemistries.

The chemistry of the fluids in the deep hydrothermal system is not known. However, it is assumed that the chemistry of the fluids from the Medicine Lake Highlands in Northern California is similar, because the two volcanos are similar in many other respects (Dames & Moore, 1994). Chemical analyses indicate that certain constituents from the Medicine Lake geothermal fluids, such as chloride, silicon dioxide, sodium, potassium, and lithium, occur at much higher concentrations than in the shallow thermal waters at Newberry Caldera. Of particular interest is the lack of sodium chloride in the waters at Newberry Caldera; sodium chloride is a common element of geothermal fluids. Newberry Caldera's thermal waters do have elevated concentrations of calcium carbonate and sulfates compared to the Medicine Lake geothermal waters. These elevated concentrations support the interpretation that the thermal waters are being heated by steam enriched with carbonates and sulfate and do not represent deep geothermal fluids such as the Medicine Lake geothermal fluids (Mariner 1980, Carothers 1987 and Dames & Moore 1994). In other words, the shallow geothermal system in the caldera does not appear to be receiving large quantities of groundwater from the deeper hydrothermal system. In this sense they are isolated from each other.

A review of regional water quality data indicates that the cold water systems outside of the caldera have no measurable interaction with the deep geothermal system at Newberry Volcano. Geothermal fluids have distinct chemical properties. There is no evidence that regional groundwater quality has been altered by contact with the deep geothermal system (Dames & Moore 1994).

3.3.5. Hydrology of the Project Area

There are no stream flows, except for Paulina Creek, and no standing surface waters (e.g., ponds, lakes) along the western flanks of the Newberry Volcano. Because of permeable soils, virtually all snow or rain runoff percolates into the ground before reaching the creek. Fresh groundwater in the project area flows west toward the Little Deschutes River.

3.3.5.1. Current Water Use

Surface water resources for Deschutes County, including Paulina Creek, are fully "appropriated," and the Oregon Water Resources Department (WRD) no longer grants new surface water rights. Concern has been raised by the WRD that groundwater resources may become depleted with continued population growth and associated development. A comprehensive groundwater resources study for the county and surrounding areas is being undertaken by the USGS and the WRD.

Water users within the upper Deschutes Basin include the communities of Bend, LaPine, and Sunriver; Avion Water Company; Roats Water Company; and users of private wells and golf courses. The City of Bend already fully utilizes its surface water appropriations from the Deschutes River and expects to develop one water well per year that would produce 3.8 million liters (1 million gallons) per day to accommodate anticipated growth. Other water users rely exclusively on groundwater wells. The closest wells to the project area, other than geothermal exploration wells, are non-community, transient wells in the campgrounds 0.8 km (0.5 mile) to the east and in the caldera, and domestic wells about 8 km (5 miles) to the west.

3.4. GEOTHERMAL RESOURCES

3.4.1. Introduction

A geothermal resource can generally be defined as a geologic accumulation of thermal energy potentially exploitable for human purposes (Anderson et al. 1988). Newberry Volcano exhibits many characteristics common to productive geothermal reservoirs elsewhere in the world. However, it is important to understand the following points in relation to this section:

- All geothermal resources have some things in common, but also have differences that profoundly affect how they can be employed and what impacts are likely to occur.

- No one yet knows enough about the specifics of this Newberry resource to accurately describe all of the impacts that are of interest. Accordingly, the environmental review and permitting process includes certain prudent checks and balances that are designed to minimize down-side consequences but still allow some demonstration-scale resource exploration, testing, development, monitoring, and evaluation.

This section describes the geothermal resource that is believed to exist at Newberry Volcano, based on publicly-available sources of information listed in the References section of this report. Geologic and hydrologic information necessary to understand the geothermal system is included in this section. More detailed regional discussions of geology and hydrology are included in separate sections of the EIS.

3.4.2. Study Area

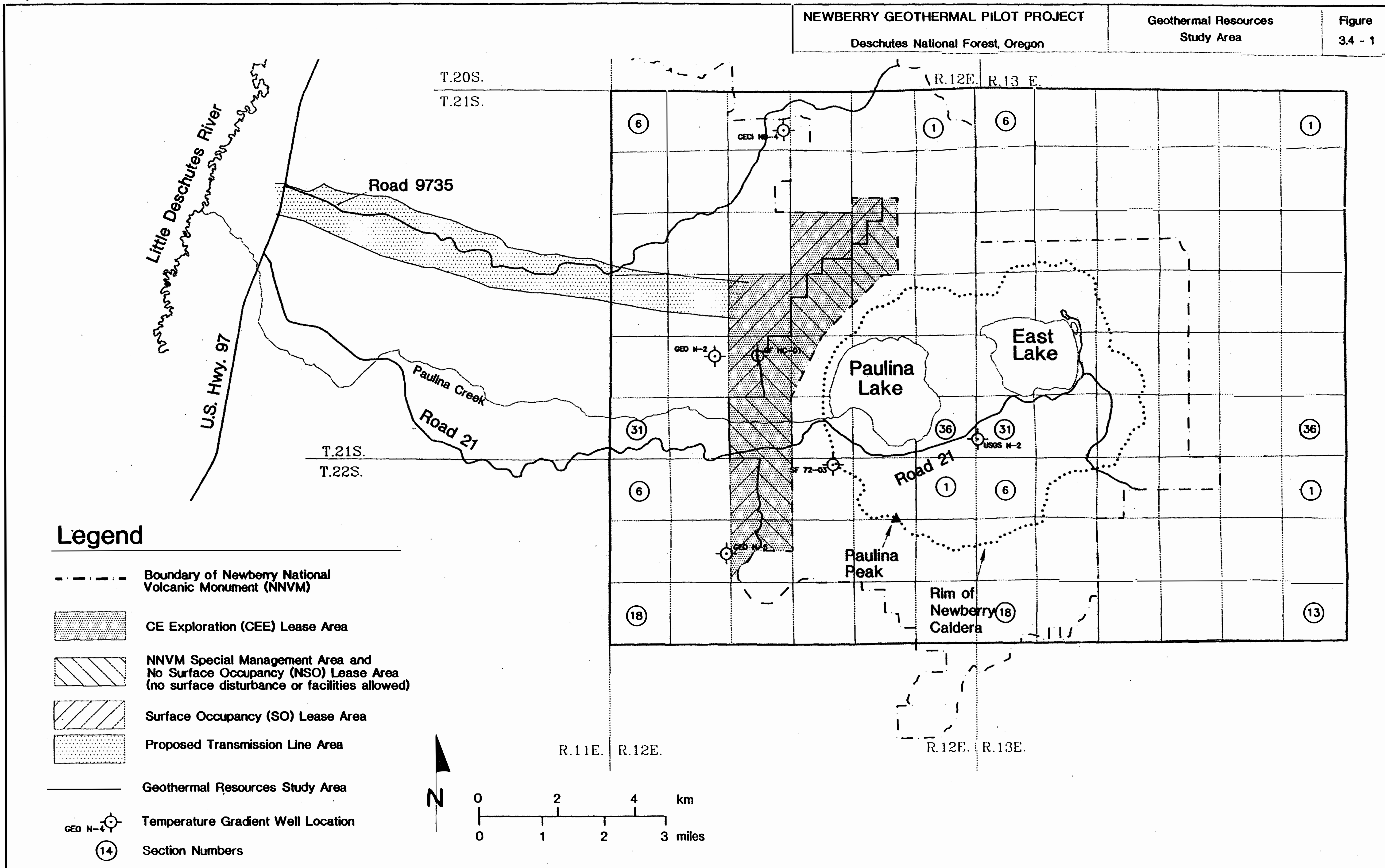
Electric power production at Newberry Volcano would use hot water (geothermal fluids) from a deep natural reservoir to generate steam for electric power production and would inject the residual water and condensed steam back into the same deep reservoir (CEE 1992). Therefore, the geothermal resources study area includes the areas of fluid withdrawal and injection (the Project Area), the geothermal system itself (probably centered beneath Newberry caldera), and a suitable buffer zone around those areas. Based on these considerations, the appropriate geothermal resources study area is shown Figure 3.4-1. The Newberry Known Geothermal Resources Area (KGRA) is shown in Figure 3.4-2. Alternatives under consideration would be located on the west flank of the Newberry Volcano within the Project Area.

3.4.3. Geologic Description of Newberry Volcano

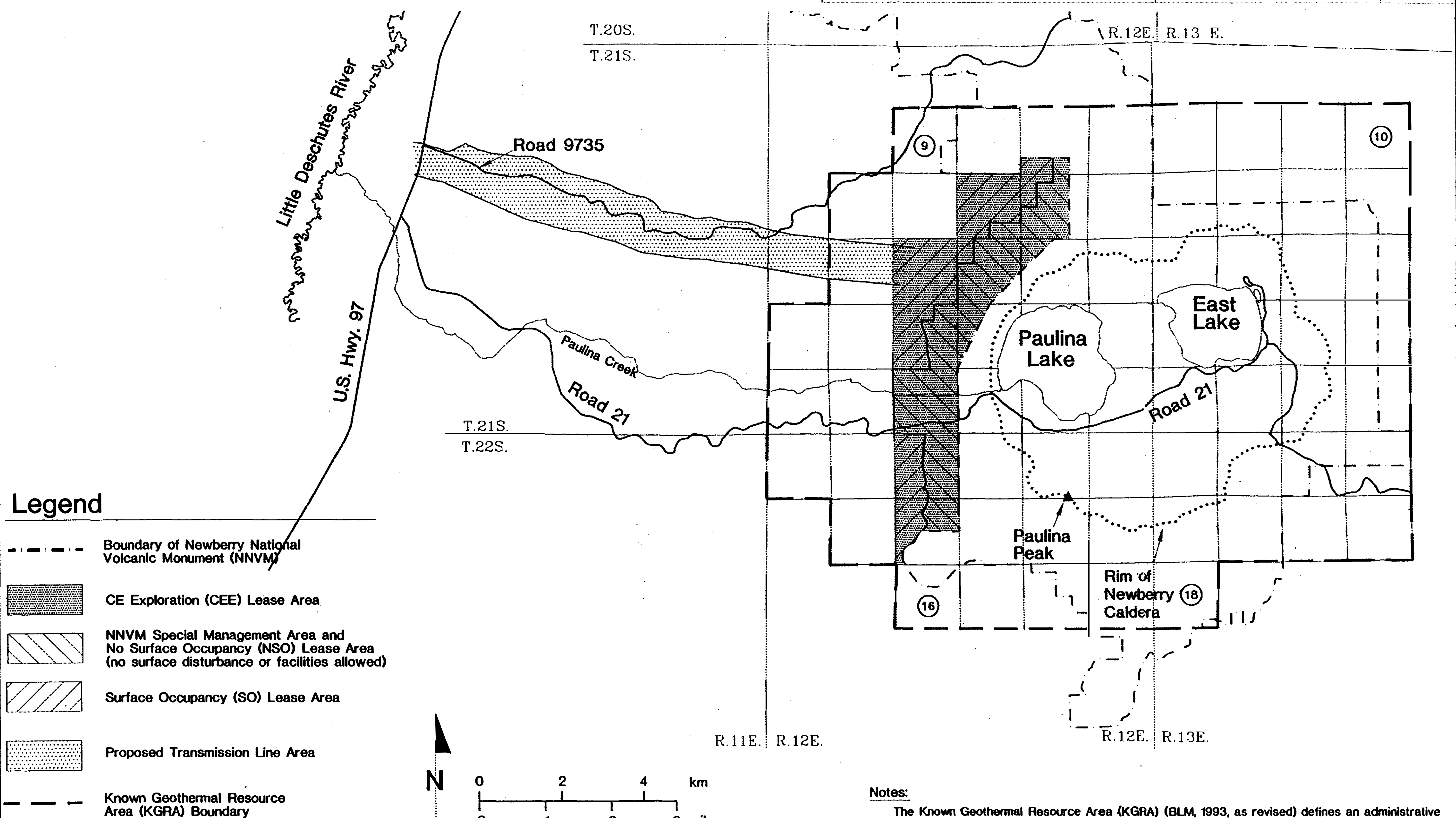
3.4.3.1. Regional Setting and Volcanism

Newberry Volcano was first visited and named by Russell in 1905, and the first full study was prepared by Williams in 1935. Since the mid-1970s, Newberry Volcano has been the subject of extensive scientific investigation by earth scientists and geothermal resource explorers (Fitterman 1988 and MacLeod et al. in press).

Located in central Oregon approximately 60 km (40 miles) east of the axis of the Cascade Range (Figure 3.4-1), Newberry Volcano is one of the largest volcanoes in the Cascades and has a complex eruptive history. As a topographic feature, it covers an area of 1,300 square km (500 square miles) extending 60 km (37 miles) north-south and 30 km (19 miles) east-west, with a 6- by 8-km (3.7- by 5-mile) diameter summit caldera rising to 1,100 meters (3,600 feet) above the surrounding terrain. Volcanic activity at Newberry began at least 500,000 years ago (Feibelkorn et al. 1983). Newberry Volcano has erupted at least 25 times in the past 10,000 years, most recently 1,350 years ago when the Big Obsidian Flow and pumice-fall deposit were erupted. Numerous recent silica-rich ("silicic") domes, breccias, and flows are present within Newberry caldera. Those less than 6,700 years old are all chemically similar (MacLeod and Sherrod 1992).


NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon
Geothermal Resources Study Area
Figure 3.4 - 1
T.20S.
T.21S.
R.12E.
R.13 E.
Little Deschutes River
Road 9735
U.S. Hwy. 97
Paulina Creek
Road 21
T.21S.
T.22S.
Paulina Lake
East Lake
Road 21
Paulina Peak
Rim of Newberry Caldera
R.11E.
R.12E.
R.12E.
R.13E.
Legend
Boundary of Newberry National Volcanic Monument (NNVM)
CE Exploration (CEE) Lease Area
NNVM Special Management Area and No Surface Occupancy (NSO) Lease Area (no surface disturbance or facilities allowed)
Surface Occupancy (SO) Lease Area
Proposed Transmission Line Area
Geothermal Resources Study Area
Temperature Gradient Well Location
Section Numbers
N
0 2 4 km
0 1 2 3 miles

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Known Geothermal Resource Area (KGRA)	Figure 3.4 - 2



Legend

- Boundary of Newberry National Volcanic Monument (NNVM)
- CE Exploration (CEE) Lease Area
- NNVM Special Management Area and No Surface Occupancy (NSO) Lease Area (no surface disturbance or facilities allowed)
- Surface Occupancy (SO) Lease Area
- Proposed Transmission Line Area
- Known Geothermal Resource Area (KGRA) Boundary
- (14) Section Number

Notes:

The Known Geothermal Resource Area (KGRA) (BLM, 1993, as revised) defines an administrative boundary. The extent of the KGRA does not delineate the boundaries of the geothermal resource, rather, it recognizes an area for which geothermal development is viewed as a potential. The actual resource may extend beyond or take a different shape than that delineated by the KGRA boundary.

Large volumes of young silica-rich volcanics, high geothermal gradients (MacLeod and Sherrod 1988), and seismic survey evidence (Achauer and Evans 1988) indicate that a magma chamber of a few to a few tens of cubic km in volume is present beneath Newberry caldera at a depth of about 3 km (2 miles) (MacLeod and Sammel 1982). Young volcanic flows and a shallow magma chamber, which can serve as a heat source for a geothermal system, are encouraging signs to explorers that a developable geothermal resource may be present. However, reports from other studies do not indicate the presence of a shallow magma body. Catchings and Mooney (1988) conducted a deep seismic refraction survey across Newberry Volcano and reported the absence of a low seismic velocity zone that would indicate the presence of a magma chamber. They concluded that a large magma chamber does not exist in the upper crust at Newberry Volcano, at least along their line of measurements. They noted that the weakening of the seismic signals they observed may be consistent with either small partially-melted magma chambers or other phenomena.

One possible model that is consistent with these conflicting observations was proposed by Linneman (1990) who suggested that Newberry Volcano was formed by repeated small-volume mafic (iron-magnesium rich) magma injections into the crust from very deep magma chambers beneath the earth's crust, followed by partial melting of the upper crust, generating the bimodal (basalt/rhyolite) volcanic style that distinguishes Newberry Volcano. Considering the various studies together, it appears likely that a small shallow magma chamber is present, providing a continuing source of heat to the hydrothermal system beneath the volcano. It also suggests the probability of future volcanic activity (Fitterman 1988). Seismic studies at Mount St. Helens (Lees 1992) and ground deformation studies at four active volcanoes (DeNatale and Pingue 1993) indicate that shallow magma chambers are commonly accompanied by ground deformation and seismic activity, which have not been reported at Newberry. This suggests that Newberry Volcano is in a period of quiescence (little or no volcanic activity) since the last eruption 1,350 years ago. The geologic cores recovered from the USGS Newberry 2 drill hole show that in the past, periods of quiescence have lasted for 2,000 to 3,000 years (MacLeod and Sherrod 1988).

3.4.3.2. Newberry Caldera

The summit of Newberry Volcano is distinctive in its steep-walled basin-like form, interpreted by geologists as a volcanic caldera. Calderas form when a volcanic edifice collapses into its magma chamber, usually accompanied by a voluminous pumice eruption. Several sets of semicircular "ring" fractures encompass Newberry's summit, suggesting that caldera collapse took place in several stages (MacLeod and Sammel 1982). At least two episodes of large pumice eruptions have been identified that are large enough to be the products of caldera collapse (MacLeod and Sherrod 1992).

Ring fractures around the caldera rim may extend vertically into the earth, or they may dip at a fairly steep angle. Dip angle is of interest because geothermal drilling will target the ring fractures as likely pathways connecting to a geothermal reservoir. Many published caldera cross-sections show ring fractures dipping toward the center of the caldera, although geologic evidence is limited about the direction that ring fractures dip. Some recent experimental studies (Komuro 1987) and seismic evidence from the actively subsiding Rabaul caldera in New Guinea (Mori and McKee 1987) suggest that collapse-caldera ring fractures form in response to magma withdrawal and that the mechanics of rock failure cause ring fractures to dip outward from the volcanic summit at steep dip angles.

At the time they are formed during caldera collapse, ring fractures probably extend from the surface down to the magma chamber, providing pathways for magma toward the surface. Dikes (cooled magma in fractures) may later seal the ring fractures. As the caldera settles and adjusts over time, seismic activity may fracture the dikes, resulting in relatively high permeability (open connected spaces) along the ring fracture system that provide a pathway for geothermal fluids to circulate. The Newberry ring fractures cut across the dense, massive basaltic andesite lava flows that have been observed in core holes. These lava flows appear to have almost no vertical permeability (Keith and Bargar 1988). Thus, ring fractures (and other geologic faults, fractures, and volcanic vents that may be present at Newberry Volcano) provide the most likely vertical pathways for circulation of hydrothermal fluids (Sammel et al. 1988).

3.4.3.3. The Lease Area

Geologic logs of geothermal drill holes show that the project area is underlain by thick sequences of basaltic andesite lava flows interbedded with volcanic cinders, scoria, and tuffs. Interlayered with the basaltic andesite sequences are silica-rich (silicic) volcanics composed of black glass flows and pyroclastic debris. Volcanic mudflows and other sedimentary rocks are occasionally present, representing periods of quiescence between eruptive events (Wermiel pers. comm. 1993).

3.4.3.4. Exploratory Drilling

Table 3.4-1 summarizes maximum temperature and depth data for five drill holes in and adjacent to the project area, and one inside the caldera. Drill hole locations are shown on Figure 3.4-1, and temperature profiles are shown on Figure 3.4-3. A conceptual cross section of Newberry Volcano is shown in Figure 1.3-2. Four drill holes located inside the project area are identified on Table 3.4-1. Temperature and heat flow data are available for these and other wells outside the project area (Blackwell 1993; Davis et al. 1990).

Table 3.4-1 Geothermal Drill Hole Data

Name	Elevation (m)	Depth (m)	$Temp_{max}$ (Deg C)	Gradient (Deg C/km)	Heat Flow (mW/m2)
INSIDE NEWBERRY CALDERA					
USGS Newberry 2	1,914	932	265	1,092	1,594
OUTSIDE NEWBERRY CALDERA					
CECI NB-4[1]	1,756	1,131	73	115	
GEO N-2[1]	1,832	1,336	164	129	200
GEO N-5[1]	1,731	988	69	126	198
Santa Fe NC-01[1]	1,832	1,220	171	138	221
Santa Fe NC 72-03	1,986	1,372	154	137	222

[1]Drill holes located within the Project Area.

[2]Gradient and heat flow data from Blackwell (1991) and Black (1991).

3.4.3.5. Drilling in the Project Area

Drilling in the project area encountered maximum temperatures in drill hole Santa Fe NC-01 of 171°C (338°F), at total depth of 1,220 meters (4,000 feet). The thermal gradient (the rate of increase of temperature with depth) was about 138°C per km (85°F per 1,000 feet) in the lower portions of the drill hole. The temperature profile of Santa Fe NC-01 is similar to that of three other wells in the project area, as described by Blackwell (1993).

Isothermal conditions extend some distance below the water table depending on local geologic conditions or possibly due to water circulation in the drill hole itself during temperature measurement (Swanberg et al. 1988). This region has been called the "rain curtain" (Swanberg et al. 1988). Blackwell (1993) examined the rain curtain effect in detail and has suggested that intrahole flow is responsible for isothermal conditions below the water table. He has stated that the bottom of the rain curtain is at most 500 to 600 meters (1,600 to 2,000 feet) deep. On the basis of constantly increasing temperatures below the rain curtain, Blackwell has concluded that the bottom of the rain curtain represents a major permeability change. Below that depth thermal conditions would be governed by conduction, not convection.

Below the rain curtain, temperature increases linearly in all drill holes in the SO lease area to total drill hole depth at a high rate compared to generally accepted crustal heat-flow values in the Cascades. The temperature gradient in Santa Fe NC-01 projected to depths below the bottom of the drill hole indicates temperatures exceeding 290°C (550°F) below 1,800 meters (6,000 feet). These temperatures would be suitable for geothermal production, provided the reservoir has adequate fluid flow.

3.4.3.6. Drilling in Newberry Caldera

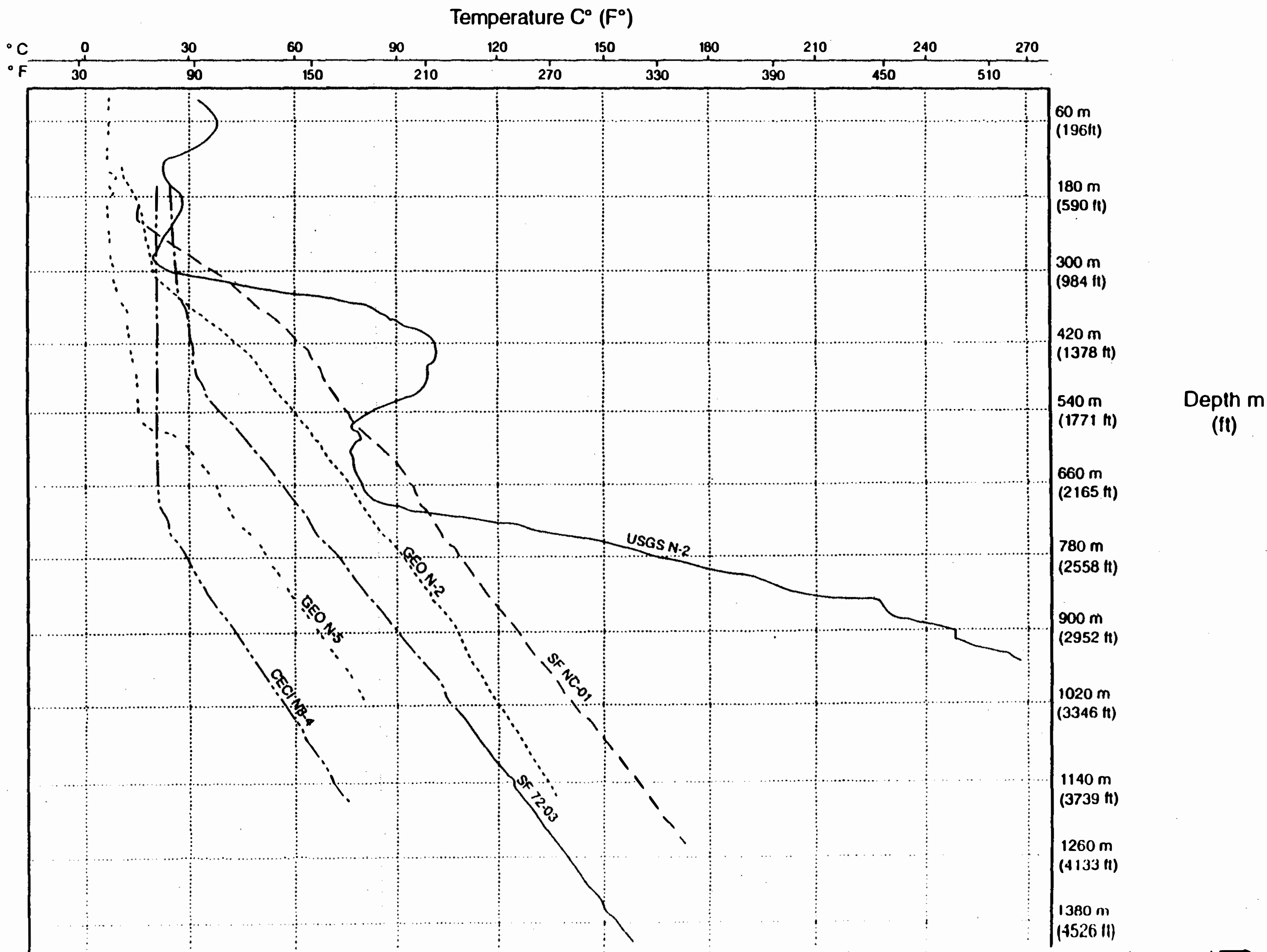
Drilling in Newberry Caldera has been described by Keith and Bargar (1988) for the USGS Newberry 2 drill hole, and by Keith et al. (1986) for Sandia Labs RDO-1 drill hole. Both wells were located near the toe of the Big Obsidian Flow. The drill cores from Newberry 2 reveal two episodes of silicic volcanism separated by a group of basaltic andesite eruptions. Also, well-sorted sedimentary rocks between 305 and 325 meters (1,000 to 1,065 feet) suggest that a single large caldera lake existed in the past. The Newberry 2 drill hole was drilled to a depth of 932 meters (3058 feet) and the RDO-1 hole to 424 meters (1391 feet). From the top down, both drill holes penetrated about 110 meters (360 feet) of silicic volcanic ash and obsidian, 200 meters (650 feet) of basaltic tuff (compacted volcanic fragments), 20 meters (65 feet) of lake sediments, and about 100 meters (300 feet) of hard silicic ash (lithic tuff). Newberry 2 was drilled below this depth through another 250 meters (820 feet) of silicic volcanic rock underlain by 240 meters (790 feet) of basaltic andesite lava flows.

There is an abrupt change of rock type from mainly fragmental and air-fall volcanics (e.g., ash, pumice, tuff) to volcanic flow rocks (e.g., obsidian, rhyolite, dacite) below 500 meters (1,650 feet) and another lithologic change to basaltic andesite flow rocks below about 700 meters (2,200 feet). The beginning of caldera formation, and the precaldera surface, could be represented by the change from flow- to air-fall volcanic styles at 500-meter (1,650-foot) depth, or alternatively to the change from basaltic andesite to silicic eruptions at 700 meters (2,200 feet). Below the precaldera surface, the volcanic sequence may be similar to that encountered in the project area.

Drill Hole Newberry 2 encountered a maximum temperature of 265°C (509°F) (Sammel 1981) at a total depth of 932 meters (3,058 feet). Lithology and rock alteration due to circulating geothermal fluids for Newberry 2 are described by Keith and Bargar (1988), who offer two alternative interpretations of the Newberry 2 temperature bulge between 425 and 547 meters (1,400 to 1,800 feet): (1) an influx of thermal water at about 425 meters (1,450 feet), or (2) an influx of cold water between 500 and 697 meters (1,650 to 2,300 feet) superimposed on an already increasing temperature gradient below 300 meters (1,000 feet). Sammel (1988) noted that there were cool water zones at 120 meters (393 feet), 275 meters (902 feet), 550 meters (1,804 feet), and 625 meters (2,050 feet) in Newberry 2. No hot water aquifers were recorded during drilling.

Drill hole Sandia RDO-1, located 500 meters (1,640 feet) southeast of Newberry 2 toward a caldera ring fracture, penetrated a shallow hot water aquifer between 380 and 397 meters (1,247 to 1,302 feet). Underground flow from this hot water aquifer could spread as far as Newberry 2 and be responsible for the temperature bulge in the upper 500 meters (1,640 feet) of Newberry 2. The inner caldera ring fracture and feeder dikes (volcanic vents) located along it, particularly the feeder dike to the 1,350-year-old Big Obsidian Flow, are possible upflow channels for thermal waters rising from a geothermal system below the caldera floor (Sammel et al. 1988, Black et al. 1984, Keith et al. 1986).

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Temperature vs. Depth from Drill Hole Data	Figure 3.4-3



Lake sediments discovered in the USGS Newberry 2 drill hole at 300 meters (985 feet) suggest that the caldera was initially much deeper than it is today and that the central area subsided 500 to 800 meters (1,640 to 2,625 feet) as measured from the present day caldera rim. Volcanic flow rocks in drill cores suggest that the precaldera land surface is at about 500 meters (1,640 feet) depth (MacLeod and Sherrod 1988) although it could be somewhat deeper. The sharp increase in temperature gradient at 700 meters (2,200 feet), which corresponds to the base of silicic flow rocks, the top of the basaltic andesite flows, and the absence of further fluid entries into the drill hole, may represent the precaldera surface. Thus, the geology and drilling results show that the caldera is 500 to 700 meters (1,600 to 2,200 feet) deep.

3.4.4. Hydrogeology

3.4.4.1. Regional Hydrogeology

Regional groundwater flow is generally to the north (for details, see Section 3.3, Water Resources). Groundwater flow occurs in the permeable volcanic strata of the Deschutes Formation and overlying layers of basalt with interstratified sedimentary and other volcanic deposits. The Clarno and John Day Formations that underlie the Deschutes Formation include stratigraphic units with low permeabilities that probably inhibit horizontal and vertical flow of regional groundwater. The depth to groundwater in the Deschutes Basin ranges from about 6 meters (20 feet) in the LaPine Subbasin to over 365 meters (1,200 feet) northeast of Newberry. The upper Deschutes Basin (also called the LaPine Subbasin) along the Little Deschutes and Deschutes Rivers west and northwest of Newberry and the underlying volcanic bedrock in the Deschutes Basin have good groundwater recharge. Due to the large annual precipitation on the eastern slope of the Cascade Range and the relatively high permeability of the area's surficial rocks and sediments, a significant amount of water infiltrates into the ground and is available to recharge the groundwater. Dames & Moore (1994) report that annual recharge to the upper Deschutes Basin groundwater is 1.4 billion cubic meters (1.1 million acre-feet) per year. Studies performed by the USGS (Sammel et al. 1988, Sammel 1983, and Phillips 1968) indicate that the net contribution from Newberry Caldera precipitation to recharge the groundwater is 3 to 8 million cubic meters (2,500 to 6,500 acre-feet) per year. Recharge on the volcano's flanks can be estimated using the surface area (approximately 1,600 square km or 600 square miles), annual precipitation (approximately 51 cm or 20 inches per year), and applying evaporative loss rates observed at Wickiup Reservoir (approximately 30 percent of annual precipitation). Based upon the above assumptions, 552 million cubic meters (448,000 acre-feet) per year seeps into the ground on the flanks of Newberry Volcano. Approximately one-half or 276 million cubic meters (224,000 acre-feet) per year would seep into the western half of the volcano and potentially flow into the upper Deschutes Basin west of Newberry (Dames & Moore 1994).

3.4.4.2. Hydrothermal System at Newberry Caldera

As indicated in Section 3.3.4, the hydrothermal system at Newberry Volcano has been extensively studied. Still, the system is poorly understood. Available concepts are simplifications of a complex hydrogeological situation. Experts agree there are three components to the groundwater system "model": (1) a limited shallow system largely confined by the caldera walls (ring fractures) and caldera floor (volcanic flows), (2) an extensive deeper system beneath the caldera floor and above the underlying magma heat source laterally connected to the regional aquifer, and (3) a system of faults and fractures and feeder dikes that provides a limited connection between the shallow and deep systems. The potential geothermal resource at Newberry Volcano for the purpose of electrical energy production is the deeper hydrothermal system that is proposed to be tested using wells drilled at the project area, located outside Newberry caldera (and outside Newberry National Volcanic Monument) on the west flank of the volcano.

A great deal of information from drilling and geophysical studies has been combined into a mental picture or "conceptual model" of the Newberry hydrothermal system described by Sammel et al. (1988).

The model proposes a high-level water table in the caldera, maintained by precipitation. Water in the caldera fill is heated by conduction from below as well as by small amounts of thermal fluid, probably mostly steam, rising through fractures and volcanic vents. Below the relatively permeable caldera-fill deposits, at depths greater than 500 meters (1,650 feet), permeabilities are extremely low in thick strata of lava flows and tuffs. These rocks form a relatively tight confining layer that isolates the shallow hydrothermal system from the deeper system of high-temperature convective flow at depths greater than 1 km (3,000 feet). In limited areas near ring faults and volcanic vents, high vertical permeabilities allow exchange of fluid between caldera fill and the deep high temperature zone. Little of the meteoric water in the caldera makes its way directly downward. Most of the water flows laterally as groundwater out of the Caldera region and into the flanks of the volcano through permeable flow tops and basal breccias such as those observed in the GEO N-1 drill hole (Swanberg 1988) and the Newberry 1 drill hole (MacLeod and Sammel 1982).

Chemical studies on different types of oxygen atoms (isotopes) by Carothers et al. (1987) from fluids produced during the Newberry 2 flow test show that some mixing of shallow and deep waters occurs. No other chemical evidence of geothermal reservoir fluids is reported in Newberry 2 production fluids (Ingebritsen et al. 1986) and the Paulina and East Lake hot springs. Hot spring waters at Paulina and East Lakes contain dissolved bicarbonate, sulfate, and sodium. The deep geothermal reservoir fluid is expected to have a different suite of dissolved ion concentrations, particularly chloride, as is found at most other hot-water geothermal areas. Chloride is only present in very low concentrations at Paulina and East Lake hot springs. The weak fumarolic activity along the toe of the Big Obsidian Flow consists mainly of carbon dioxide gas, with no reports of hydrogen sulfide gas. Thus, there is no appreciable evidence for mixing of deep and shallow geothermal fluids based on surface water chemistry. No fluid from the deep reservoir has been detected on the flanks of Newberry Volcano or in nearby streams (Sammel et al. 1988).

3.4.4.3. Project Area

Geothermal conditions in the project area differ significantly from conditions in the caldera. No surface manifestations of hydrothermal activity are present in the project area. No shallow hydrothermal system has been detected in the project area. On the contrary, the regional aquifer is estimated to be about 490 meters (1,600 feet) deep and isothermal conditions near atmospheric temperature above that depth.

No productive geothermal wells have been drilled in the project area, thus the existence of a geothermal resource is questionable. On the other hand, the project area lies immediately west of the inner caldera ring fault and may be traversed by other ring faults and fractures having little surface expression that are hydraulically connected to a geothermal reservoir beneath Newberry Caldera. Bottom hole temperatures and temperature gradient data from the core holes in the project area indicate the proximity of a geothermal system. Geophysical data, particularly electrical resistivity soundings (Fitterman et al. 1988) and mineral alteration in drill hole cores (Wermeil 1993), suggest that elevated temperatures and hydrothermal fluid movement is occurring at depth beneath the project area. Seismic studies of compression waves have indicated a zone of high attenuation under the proposed project area that has been interpreted as a region of boiling water (Zucca and Evans, 1992).

3.4.5. Geothermal Potential

Using two different sets of assumptions, potentially sustainable geothermal energy production at Newberry Volcano has been recently estimated by Black (1993) at either 20 to 200 megawatts (MW) or 200 to 2,000 MW.

The lower range (20 to 200 MW) results from assuming that Newberry Volcano shares the characteristics of other Cascade Range volcanoes, expected to have very low recovery factors

(0.01 to 0.1) relative to total thermal energy. The recovery factor is the ratio of geothermal energy available at the surface to geothermal energy originally in the reservoir.

The upper range of potential energy production (200 to 2,000 MW) results from assuming that Newberry Volcano has a recovery factor of 0.25 based on an effective porosity of 20 percent (Brook et al. 1978) which Black (1993) points out may be valid for the hydrothermal convection systems for which it was designed, but is not valid (too high a recovery factor) for Cascade Range volcanoes in general.

At Newberry Volcano, where a hydrothermal convection system and magmatic heat source are apparently present, a recovery factor of 0.25 may be valid for portions of the volcano (Black, 1993). Thus Newberry's geothermal potential is estimated to be in the range of 200 to 2,000 MW, probably toward the lower end of the range.

The assumptions and calculations used by Black (1993) and Brooke et al. (1978) do not take into account an abandonment temperature for power generation. They are based on the total geothermal fluid heat content. Over time, the temperature of water-dominated geothermal reservoirs may drop to a point where power generation is economically not feasible with the installed technology. At this temperature, facilities would have to be replaced or modified, or power generation must be abandoned. Such a drop in temperature generally would be due to an intrusion of cooler water into the reservoir. At the abandonment temperature, which will vary depending on the type of heat extraction technology, production well depth and other factors, the geothermal fluid would retain a certain amount of unrecoverable energy. Thus, the theoretical energy estimates stated above are higher than the actual recoverable energy by an unknown amount (Chitwood 1993; McClain 1993).

3.4.6. Geothermal Resource Fluid Composition Assumptions

Newberry Volcano and Medicine Lake Volcano in northern California have several notable geologic similarities (Linneman 1990). The Medicine Lake highlands are situated in a caldera similar to Newberry (Dames & Moore 1994). Both volcanoes probably have small shallow magma chambers heating hydrothermal systems beneath their summit areas. Whereas geothermal drilling at Newberry has discovered a limited hydrothermal system in the caldera fill, drilling at Medicine Lake has tapped a deeper reservoir. Table 3.4-2 illustrates the chemical differences between the thermal springs at East Lake and Paulina Lake, and geothermal fluids analyzed from geothermal test wells located in the Medicine Lake Highlands in northeast California. Chemical analyses show that certain constituents from the Medicine Lake geothermal fluids (i.e., chloride, silicon dioxide, sodium, potassium, and lithium) exhibit much higher concentrations than the thermal waters at Newberry. Of particular interest is the lack of sodium chloride at Newberry, which is a common element of geothermal fluids. The low concentration of these constituents supports the interpretation that Newberry's thermal waters do not represent deep geothermal fluids. Newberry's thermal waters do have elevated concentrations of calcium carbonate and sulfates compared to the Medicine Lake geothermal fluids. These elevated constituents support the interpretation that the thermal waters are being heated by steam enriched with carbonates and sulfate.

3.5. CLIMATE AND AIR QUALITY

3.5.1. Study Area

The study area for the discussion of air quality includes the project region and extends to the closest Class 1 (air-quality sensitive) area. The closest Class 1 area is the Three Sisters Wilderness Area and is located to the north-northwest of the CEE leases. The distance from the proposed project to the closest boundary of the Class 1 area is approximately 43.5 km (27 miles). This study area was selected to include areas that were considered because of their sensitivity to air quality impacts. The study area also includes the cities of Bend, Sunriver, and LaPine. Figure 3.5-1 shows the study area.

Table 3.4-2 Chemical Analyses of Thermal Waters

Constituent	East Lake[1] Hot Springs	Paulina[1] Hot Springs	Medicine Lake Test Wells[2]
pH	6.4	6.8	8.4
	Concentrations in mg/l (Parts per Million)[3]		
Silica (SiO_2)	100	205	690
Sodium (Na)	53	140	980
Potassium (K)	3.8	17	158
Calcium (Ca)	70	56	25.9
Magnesium (Mg)	34	60	1.7
Bicarbonate (HCO_3)	547	856	27
Sulfate (SO_4)	58	<1.0	46
Chloride (Cl)	1.7	6.0	1,759
Lithium (Li)	0.04	0.22	6.3

Notes:
All values in mg/l (parts per million); highest reported values shown.
[1]Source: Mariner, 1980
[2]Source: CE Exploration Company, 1994
[3]Highest reported values shown

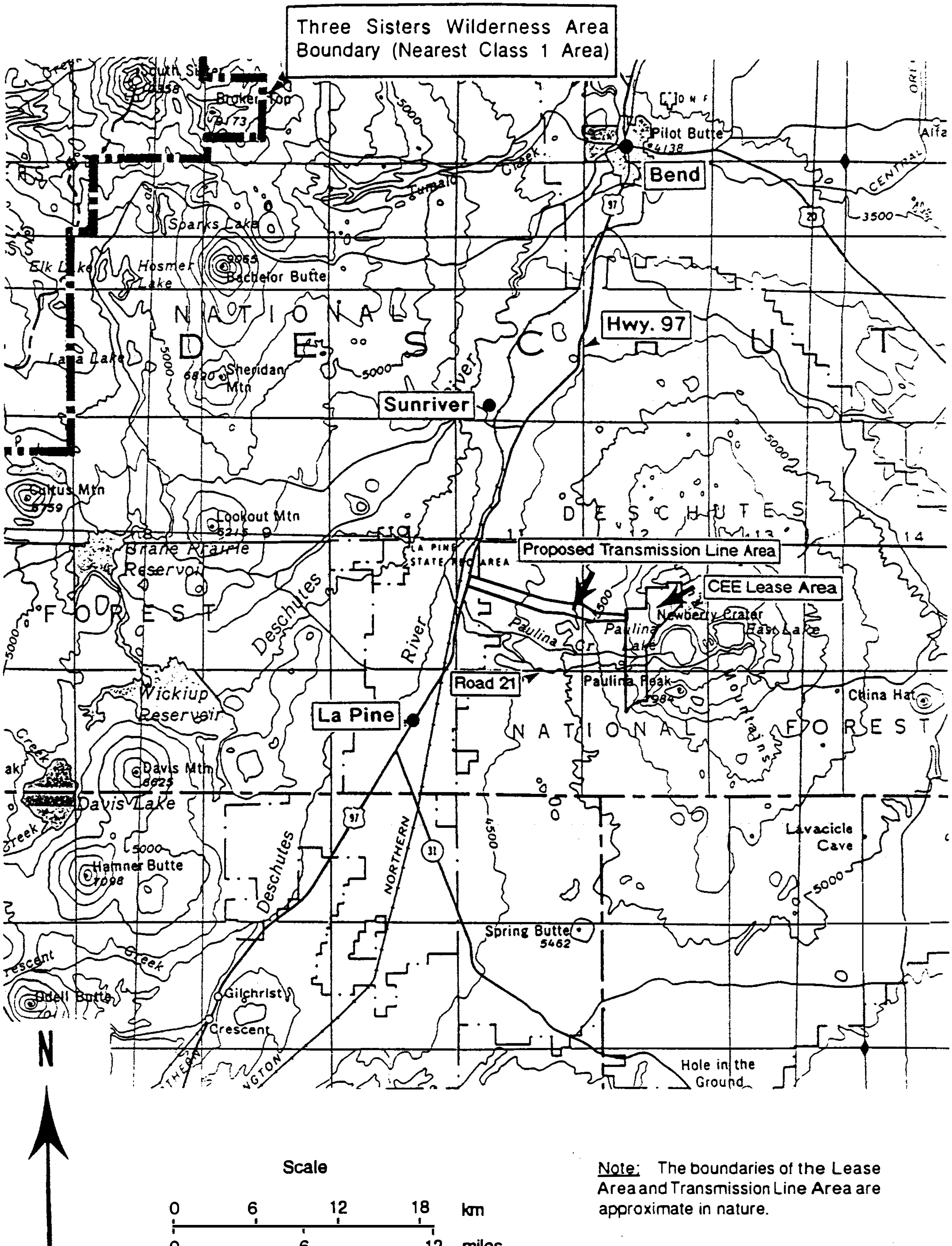
3.5.2. Existing Conditions

3.5.2.1. Setting

The proposed project is located in a rural setting, absent of substantial air pollutant emissions. Much of the project vicinity is managed either by the BLM or the U.S. Forest Service for forest products, rangeland, or recreational uses. Principal regional man-made sources of air pollution are wind-blown dust from exposed soils (forestry and development), road dust, vehicular exhaust emissions, and smoke and particulate matter from infrequent slash burning, which has been on the decline with recent market demands for wood and better utilization technology. Deschutes County is estimated to be responsible for a small portion (approximately 2 to 3 percent) of Oregon's total regulated air pollutant emissions (see Appendix F-1).

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 such as dirt road travel and infrequent forest slash burning can contribute to occasional locally elevated air pollution levels. This situation is not unique; it is typical of most rural semi-arid and arid areas of the U.S. Although no ambient air monitoring has been done in the project area, the Oregon Department of Environmental Quality considers the area to be in attainment of all state and Federal ambient air quality standards. In addition, based on the characteristics of local emission sources and the geographical area, the area is unquestionably in attainment of all air quality standards.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Air Quality Study Area	Figure 3.5-1



Note: The boundaries of the Lease Area and Transmission Line Area are approximate in nature.

3.5.2.2. Climate and Meteorology

Climate in the project region is typical of a semi-arid high desert, which experiences cold, moist winters and warm, dry summers. The average annual precipitation within the Newberry caldera is approximately 89 cm (35 inches) (Appendix F-5). Meteorological data were collected from September 26, 1992 to August 13, 1993, near the proposed project site for use in air quality modeling. Wind speed, wind direction, and a measure of atmospheric stability data were collected by CEE. Wind roses for the data are contained in Appendix F-4. The wind data revealed a diurnal pattern in wind direction, with east and southeast winds occurring most frequently at night and winds from the west most frequently occurring during the day. Because of the elevation and surrounding topography, stagnation events in the project vicinity are uncommon (Branig 1993).

3.5.2.3. Air Quality Standards/Guidelines

Air quality standards have been set by the U.S. EPA under the Federal Clean Air Act (most recently amended in 1990) and by the state of Oregon DEQ. These standards fall into two general categories: emission standards that apply to direct sources and ambient standards that limit air pollution levels in a given area. For a more detailed discussion of air quality regulations, see Appendix E.

Pollutants for which ambient air quality standards have been established are known as "Federal Criteria" pollutants. The Clean Air Act defines six criteria pollutants for which national ambient air quality standards have been established. Ambient standards and guidelines are listed in Table 3.5-1 for Criteria pollutants and air toxics that the project is expected to emit.

The national ambient air quality standards (NAAQS) are defined as levels of specific air pollutants above which detrimental effects on human health and welfare may result. The standards are expressed in terms of different averaging times; for example, annual, 24-hour, and 3-hour. An area that is found to be in violation of NAAQS is called a "nonattainment area." Pollution sources contributing to nonattainment areas are subject to tighter restrictions. This project is not within and would not significantly affect a nonattainment area.

Another provision of Federal and state regulations is "Prevention of Significant Deterioration" (PSD). The premise behind PSD regulations is to prevent areas that currently have clean air from being polluted to the maximum allowed by NAAQS (see Appendix E). Three air quality classes were established, Class I, Class II, and Class III. Class I areas are subject to the tightest restrictions on how much additional pollution (usually called an increment) can be added to the air. The proposed project is located in a Class II area. The two closest Class I areas to the proposed project are the Three Sisters Wilderness Area and Crater Lake National Park. There are no Class III areas in existence today.

The Three Sisters Wilderness Area is the nearest Class 1 area (Figure 3.5-1). Its boundary is located approximately 43.5 km (27 miles) north-northwest of the project area. Other sensitive areas (Class II) considered for air quality baseline and impact analysis include locations within the Newberry National Volcanic Monument boundary at a closest distance of 1,700 meters (5,600 feet), a bald eagle nesting area in the Monument at a distance of 7 km (4.3 miles), and the City of Bend at 30 km (19 miles). A total of 18 sensitive receptors were evaluated for air quality impacts. These are identified in Appendix F-4, Table 4.

The project region is in compliance with Federal and state air quality standards. The closest area which has occasionally exceeded NAAQS for particulates is Klamath Falls, Oregon, located approximately 170 km (105 miles) south of the project area. The air quality conditions in Klamath Falls have improved dramatically due to both a wood burning curtailment program and an aggressive public education program. Klamath Falls had only one exceedance in fine particulates in 1992 as compared to 22, 28, 45, 18, and 7 exceedances for years 1987-1991, respectively. This single exceedance was associated with wind-blown dust (Oregon Department of Environmental Quality 1993).

Any new air contaminant source that emits "significant" levels of air pollutants (and thus is considered a "major source") must undergo a New Source Review. "Significant" emission levels are defined in DEQ regulations. As part of this review, PSD applicability is determined. New air pollution sources (including minor sources that do not trigger impact modeling requirements) are not allowed by state and Federal air laws/regulations to cause or contribute to violations of the state/Federal ambient air quality standards or allowable PSD increments.

Hydrogen sulfide (H_2S), although not regulated under Federal or state AAQS, as a Criteria pollutant, or under Oregon's Interim Air Toxic Program, is the principal air pollutant associated with the geothermal industry, in large part due to its low olfactory (odor) threshold. Since Oregon does not have an ambient standard for H_2S, the California standard has been used for this baseline evaluation (see Table 3.5-1). These standards were established to protect against nuisance odors that may occur, and also protect against health effects that occur at much higher concentrations.

Oregon has an established policy for air toxics. It is known as the Interim Toxic Air Pollutant Policy. The policy defines significant air toxic sources in the state of Oregon by establishing Significant Emission Rates (SERs). Oregon's SERs are based on human health effect levels. The Acceptable Ambient Levels (AAL) shown in Table 3.5-1 are based on these SERs.

3.5.2.4. Baseline Air Quality Data

Air quality monitoring data are not available for the project vicinity. A baseline study has estimated background concentrations for Federal and state criteria pollutants and air toxics which are associated with the geothermal industry and which would be regulated by DEQ. A copy of this study is contained in Appendix F-1. Because existing data for Newberry were not available, mean background levels from other locations were used to estimate the air quality conditions at Newberry. Mean background levels of PM_{10} (respirable particles smaller than 10 microns), SO_2 (sulfur dioxide), and Pb (lead) were utilized from Crater Lake data. Ozone measurements made by the U.S. Forest Service for the Three Sisters Wilderness Area were used. Unpolluted background levels typical of the western United States were used for the CO (carbon monoxide), NO_2 (nitrogen dioxide), H_2S (hydrogen sulfide), NH_3 (ammonia), and VOC (volatile organic compounds) values. These data are believed to typify the ambient concentrations for these pollutants in the project region.

Background air quality estimates from Appendix F-1 are summarized in Table 3.5-1, along with applicable ambient air quality standards and PSD increments, and air toxic guidelines.

H_2S is present in the atmosphere within the caldera from existing natural geothermal vents. The odor of H_2S is occasionally detectable near the fumaroles near the Big Obsidian flow and at the East Lake Hot Springs. These localized sources of H_2S do not contribute a substantial amount of H_2S in the atmosphere, and have only localized odor effects.

Boron, ammonia, and volatile organic compounds are also associated with the geothermal industry, although to a lesser degree than H_2S, and were included in the background ambient air quality analysis. In addition, volatile organic compounds are responsible in part for low elevation atmospheric ozone production and may contain some air toxics.

TABLE 3.5-1
Background Air Pollutants

Pollutant	Chemical Symbol or Abbreviation	Category	Estimated Mean Background Concentration	Standards or Guidelines and PSD* Increments
Particles less than 10 microns	PM_{10}	Criteria Pollutant	9.45 μg/m³	50 μg/m³ annual arithmetic mean 150 μg/m³ 24-hour max. 5 μg/m³, Class I, increment for annual geometric mean 10 μg/m³ Class I, increment for 24-hour maximum 19 μg/m³, Class II, annual increment for annual geometric mean. 37 μg/m³ Class II, increment for 24-hour maximum[1]
Sulfur dioxide	SO_2	Criteria Pollutant	0.457 μg/m³ (1.75 x 10^{-4} ppm)	0.02 ppm annual arithmetic mean 0.10 ppm 24-hour max. 0.5 ppm 3-hour max. 2 μg/m³ Class I, increment for annual arithmetic mean 5 μg/m³ Class I, increment for 24-hour maximum 25 μg/m³ Class I, for 3-hour maximum 20 μg/m³ Class II, increment for annual arithmetic mean 91 μg/m³ Class II, increment for 24-hour maximum 512 μg/m³ Class II, for 3-hour maximum
Carbon monoxide	CO	Criteria Pollutant	0.1 ppm	9 ppm 8-hour 35 ppm 1-hour
Ozone	O_3	Criteria Pollutant	0.025-0.030 ppm[10]	0.12 ppm 1-hour
Nitrogen dioxide	NO_2	Criteria Pollutant	0.002 μg/m³ (0.001 ppm)	0.053 ppm annual arithmetic mean 2.5 μg/m³ Class I, increment for annual arithmetic mean 25 μg/m³ Class II, increment for annual arithmetic mean
Lead	Pb	Criteria Pollutant and Air toxic	1.2 x 10^{-3} μg/m³	1.5 μg/m³ calendar quarter
Antimony	Sb	Air toxic	<9 x 10^{-7} μg/m³	1.7 μg/m³ AAL[1]
Arsenic	As	Air toxic	6 x 10^{-6} μg/m³	0.7 μg/m³ AAL[1]
Beryllium	Be	Air toxic	6 x 10^{-6} μg/m³	0.007 μg/m³ AAL[1]
Cadmium	Cd	Air toxic	<4 x 10^{-7} μg/m³	0.033 μg/m³ AAL[1]

TABLE 3.5-1
Background Air Pollutants (Continued)

Pollutant	Chemical Symbol or Abbreviation	Category	Estimated Mean Background Concentration	Standards or Guidelines and PSD* Increments
Chromium	Cr	Air toxic	2×10^{-4} µg/m^3	1.7 µg/m^3 AAL [1]
Cobalt	Co	Air toxic	7×10^{-5} µg/m^3	0.17 µg/m^3 AAL [1]
Manganese	Mn	Air toxic	2×10^{-3} µg/m^3	17 µg/m^3 AAL [1]
Mercury	Hg	Air toxic	0.01 µg/m^3	0.17 µg/m^3 AAL [1,2]
Nickel	Ni	Air toxic	2×10^{-5} µg/m^3	3.3 µg/m^3 AAL [1]
Selenium	Se	Air toxic	$<4 \times 10^{-6}$ µg/m^3	4 µg/m^3 AAL [1]
Radon-222	^{222}Rn	Air toxic	0.13 pCi/l	4 pCi/l [3]
Boron	B	Geothermal pollutant	7×10^{-5} µg/m^3	33 µg/m^3 AAL [1,4]
Hydrogen sulfide	H_2S	Geothermal pollutant	0.2 ppb (0.28 µg/m^3)	30 ppb [5] (41.7 µg/m^3)
Ammonia	NH_3	Geothermal pollutant	0.01 ppm	3.1 ppm [6] (0.129ppm) [1]
Volatile organic compounds	VOC	Many air toxics are VOC & O_3-producing	200 ppb	NA
Total suspended particles	TSP	Oregon State and PSD air pollutant	13.1 µg/m^3	60 µg/m^3 annual geometric mean [7] 150 µg/m^3 24-hour max. [7] 5 µg/m^3 Class I, increment for annual geometric mean [2] 10 µg/m^3 Class I, 24-hour increment 19 µg/m^3 Class II, increment for annual geometric mean 37 µg/m^3 Class II, 24-hour increment

Source: SAIC 1993. See Appendix F-1.

1 Acceptable ambient levels (AAL) determined from Occupational Threshold Limit Values (TLV) per Oregon's Hazardous Air Pollutant Interim Program
2 Mercury vapor
3 Federal indoor air standard; not considered an outdoor air toxic hazard.
4 Boron oxide
5 California 1-hour standard, an odor-based standard that is used as an impact indicator in this EIS, since an ambient standard does not exist in Oregon
6 Alaska 1-hour standard
7 Oregon standard

*Note: PSD increments are not an ambient standard but rather an incremental amount of change in background concentration of a given pollutant which cannot be exceeded.

Another existing source of ambient air pollutants is soil. On a local level, fugitive dust on windy days contributes to atmospheric concentrations of air toxics. Native soils naturally contain trace amounts of metals and other elements. The predominant soil type in the project area is composed of Mazama ash. Compositional data for this ash combined with Crater Lake particulate monitoring data allowed for the calculation of estimated average S, As, Be, Cd, Cr, Co, Mn, Ni, Se, and B atmospheric levels in the project area. Average TSP levels were estimated from the Crater Lake PM_{10} monitoring data and the size distribution typical of local soils (see Appendix F-1).

Soil gas measurements have been made for mercury (Hg) and radon-222 (Rn-222) as part of the geothermal exploration that has been conducted at Newberry Volcano. Soil gas samples have a median value for Hg around 75 parts per billion (ppb) with a range from 21 to 1,293 ppb. These values are low when compared to the 500 ppb for Hg background levels in soils in the western U.S. Soil gas samples for Radon-222 have a mean value of 50.8 picocurries per liter (pCi/l) of soil gas. This value is low when compared to the worldwide average of 80.2 pCi/l. From the soil gas measurements, typical atmospheric Hg and Rn-222 estimates were developed to provide an estimated atmospheric value. Since mercury is a volatile metal, vapor emanating from subsurface geothermal features in the project region can be a more significant fraction of total airborne mercury than solid-phase mercury contained in soil particles. Radon is only a gas at ambient conditions, and is a decay product of uranium in natural soils and rock.

Except for Pb, Rn-222, and Hg, the atmospheric concentrations of air toxics are primarily influenced by the amount of soil dust in the air. Even in a rural airshed, the primary source of atmospheric Pb is commonly exhaust from vehicles using leaded gasoline, especially when measurements are taken in the vicinity of roads.

3.5.2.5. Visibility

Regulations have been promulgated for visibility protection of PSD Class 1 areas (OAR 340-20-047). Considerable visibility monitoring has been conducted by DEQ in the Cascade wilderness areas and at Crater Lake National Park. Forest fires and local fugitive dust on windy days mentioned above are expected to have infrequent impacts on visibility.

Most relevant to the project are data for the Three Sisters Wilderness Area, because this is the nearest Class 1 area. The 90th percentile value is used in both the visibility modeling and the quantitative determinations of human perceptibility of visibility impairment. The 90th percentile represents the visual range that is equalled or exceeded 10 percent of the time. The 90th percentile value for the time period 1986 through 1990 averaged 234 km (146 miles) at the Three Sisters Wilderness Area, indicating very high quality visibility conditions (Appendix F-3).

3.5.2.6. Global Warming

Throughout the world, energy is obtained and goods and services produced primarily through the burning of fossil fuels. These combustion processes, while providing a practical energy source, emit CO_2 and increase the amount present in the earth's atmosphere. Many experts within the scientific community believe that the increase in CO_2 is leading to a global temperature increase, or global warming, because CO_2 and other greenhouse gases trap heat in the earth's atmosphere. There is presently some controversy over the scale and timing of these effects, but many people believe that global warming could have adverse effects on life on earth.

Over the past century, the mean global temperature has been estimated to have increased 0.5 degrees Celsius (Schneider 1989). While there is some debate in the scientific community as to whether this temperature increase can be attributed to the greenhouse effect vs. natural causes (e.g., variability in solar activity), the greenhouse effect and its potential effect on global climate are of concern. The extent to which climatic changes caused by global warming may prove significant in the future depends on the rate of release of carbon dioxide and other greenhouse gases into the atmosphere.

The United States contributes about 20 percent of the world average of carbon emissions per capita; Oregon adds only a fraction of one percent (Oregon Department of Energy 1990). Oregon's contribution is mostly from the burning of fossil fuels, which creates carbon dioxide.

3.5.2.7. Additional Regulatory Aspects

Meteorological conditions have been monitored and reported at the plant site since October 1992.

A baseline air quality monitoring program would be implemented by the applicant prior to operation of the proposed geothermal facilities as required by the GRO Order No. 4. Program plans would be reviewed and approved by DEQ, the U.S. Forest Service, BLM, and other agencies prior to implementation.

3.6. VISUAL RESOURCES

3.6.1. Introduction

The objectives of the visual resource baseline inventory were to identify, describe, and map all significant visual resources which may be affected by the construction and operation of the proposed geothermal project and ancillary facilities. The baseline data were recorded in sufficient detail for assessment of direct and indirect impacts of the project. The visual resource study was conducted in compliance with Federal guidelines established by the U.S. Forest Service Visual Management System. The visual analysis reflects information from the 1990 Deschutes National Forest Land and Resource Management Plan, and describes the Visual Quality Objectives currently applied to management of the area. The terminology used in this section is consistent with that used in the Visual Management System. Chapter 8 is a glossary of terms commonly used in this section.

3.6.2. Study Area

effects of the proposed project are estimated to encompass an area along the western edge of the High Lava Plains of central Oregon and approximately 2.1 km (13 miles) east of the Deschutes River along the western edge of the Paulina Mountains (Franklin and Dyrness 1973). This constitutes the project study area for the visual resources analysis. The borders of this study area were based on an area of visual influence or potential view shed containing the proposed project facilities and construction and operation activities. The study area was refined by means of a generalized visual analysis of the relationship of the proposed project to the surrounding topographic and vegetative patterns.

3.6.3. Scenic Value Designations

The U.S. Forest Service conducted a visual resource inventory in 1976 which includes the study area. The U.S. Forest Service Visual Management System (VMS) inventory included mapping-variety classes broken down into "Common," "Distinctive," and "Minimal" sensitivity levels for travel routes, and visual quality objectives (VQO) (standards by which visual and aesthetic resources in the U.S. Forest are managed). The inventories of existing visual condition (EVC) and visual absorption capability (VAC) (defined as the relative ability of a landscape to withstand land manipulation without affecting its visual character or integrity) were developed using aerial photography, USGS quadrangle sheets, and orthophotos. The VQO inventory was refined by orthophoto interpretation and limited field verification. A summary of the visual resources inventory for the proposed project facilities is presented in Table 3.6-1.

3.6.4. Existing Conditions

The study area, known for volcanic activity, is visually evident by numerous landforms, volcanic cones, and lava buttes rising from the surface of the surrounding lava plateau, and by the presence of lava flows. The Newberry Caldera contains two large lakes, Paulina and East lakes.

Homogenous vegetative patterns present in the study area are dominated by mature stands of lodgepole pines, which are broken by areas of clearcuts.

The project lease area is located in two VQO categories as shown in Figure 3.6-1. The proposed power plant and wells would be located in a VQO allocation of Partial Retention where visual quality standards require proposed project facilities and activities to remain visually subordinate to the characteristic landscape. Most of the transmission line area would be located within the Modification VQO where project activities and facilities may dominate the landscape. Eighty percent of the SO lease area would be in the Partial Retention allocation and 20 percent in the Modification allocation. Ten percent of the transmission line area, 1,810 hectares (4,472 acres) would be in the Partial Retention allocation and 16,287 hectares (40,244 acres) or ninety percent, would be in the Modification allocation.

Table 3.6-1 Summary of Existing Conditions for Visual Resources

Proposed Project Facility	VQO[1]	VAC[2]	EVC[3]	Visibility[4]
Plant Sites	PR	M-H	D-MAJ	L-M
Well pads	PR	M-H	UNN-MAJ	L
Access Roads	PR/M	M-H	MIN-MAJ	L
Gathering System	PR	H	UNN-MAJ	L
Transmission Line Area	PR/M	M-H	UNN-MAJ	L-M

Source: U.S. Forest Service, field reconnaissance, and color aerial photography.

[1]VQO - Visual Quality Objective: PR - Partial Retention, M - Modification
[2]VAC - Visual Absorption Capability: H - High, M - Moderate, L - Low
[3]EVC - Existing Visual Condition: UNN - Unnoticeable, MIN - Minor Disturbance, D - Disturbed, MAJ - Major Disturbance
[4]L - Low, M - Moderate, H - High
(The Visual Quality Objectives in the Forest Plan Standards and Guidelines refer to the Visual Quality Standards Map published with the Forest Land Resource and Management Plan. These are considered as inventory maps and do not provide direction unless specifically referred to for specific Management Areas. The Management Areas of the project area are not included in this group.)

The lease area is located over several EVC zones (Figure 3.6-2). The Forest Plan has classified the project area into two management areas (MA). The proposed power plant site, well pads, and gathering system would be in MA9 - Scenic Views. The transmission line area would be in MA8 - General Forest (see Figure 3.8-1).

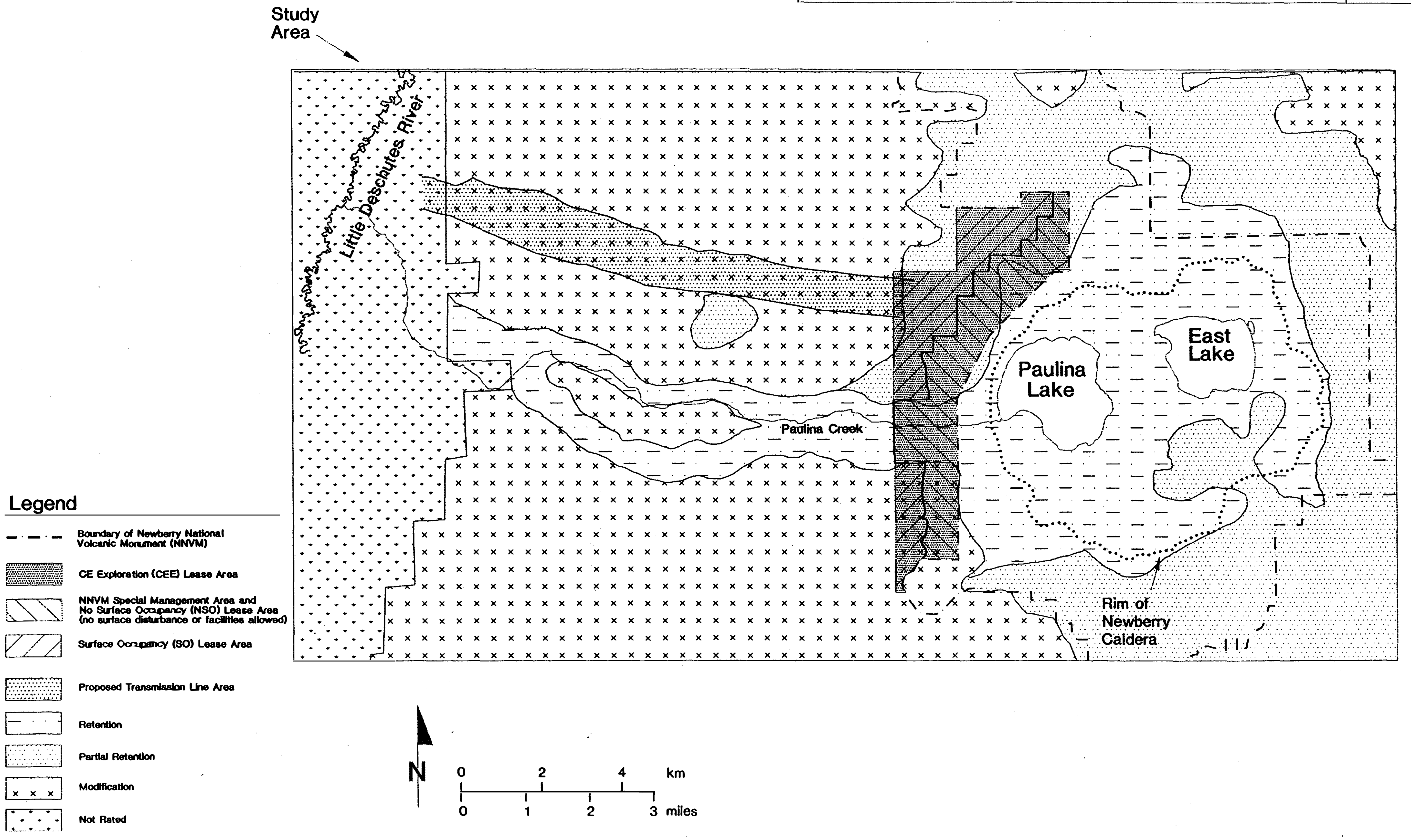
The VAC for the proposed lease area ranges from moderate to high. The vegetation type over this area is predominantly even-aged stands of lodgepole pine averaging 18 to 21 meters (60 to 70 feet) in crown height. Some variation in topography adds to a higher VAC.

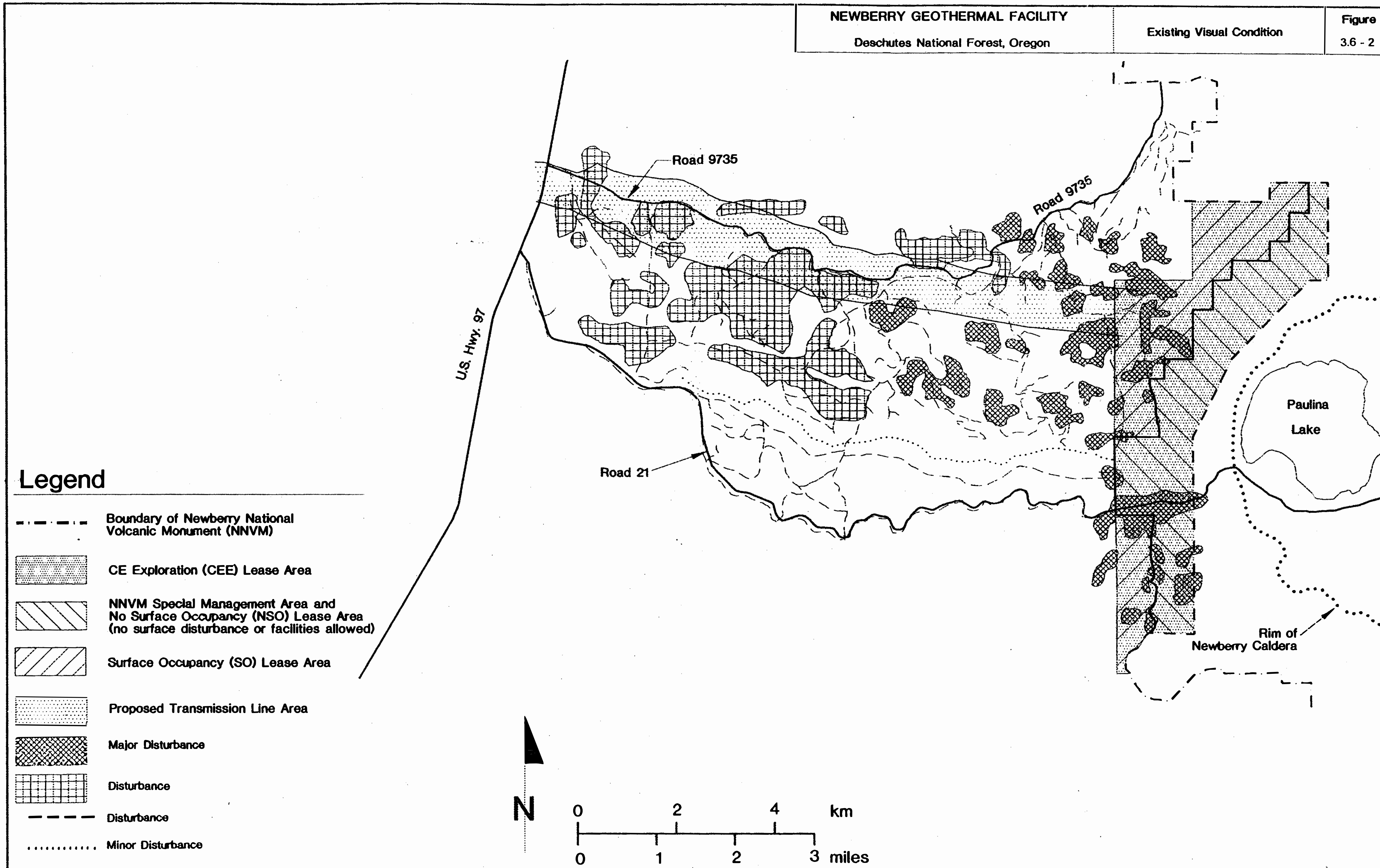
NEWBERRY GEOTHERMAL PILOT PROJECT

Deschutes National Forest, Oregon

Visual Quality Objectives in the Project Area

Figure 3.6 - 1





NEWBERRY GEOTHERMAL FACILITY
Deschutes National Forest, Oregon
Existing Visual Condition
Figure
3.6 - 2
Road 9735
Road 9735
U.S. Hwy. 97
Road 21
Paulina
Lake
Rim of
Newberry Caldera
Legend
Boundary of Newberry National Volcanic Monument (NNVM)
CE Exploration (CEE) Lease Area
NNVM Special Management Area and No Surface Occupancy (NSO) Lease Area (no surface disturbance or facilities allowed)
Surface Occupancy (SO) Lease Area
Proposed Transmission Line Area
Major Disturbance
Disturbance
Disturbance
Minor Disturbance
N
0
2
4
km
0
1
2
3
miles

3.7. NOISE

3.7.1. Noise and Its Measurement

Noise is commonly defined as unwanted sound that disrupts normal human activities or diminishes the quality of the human environment. Some authorities suggest that noise also diminishes the quality of animal habitat. However, whether the effect on animals is due to human presence and its noise, to the noise alone, or the human presence alone, has not been demonstrated. The total noise level is composed of a typical mix of transient (i.e., passing aircraft, vehicles) and stationary (i.e., machinery, pumps) noise sources, both distant and nearby, which form the ambient noise environment at the measurement location.

Noise is measured as a sound pressure level exerted on the microphone of a sound meter. The magnitude of audible sound levels, decibels (dB), has a very wide range. Decibel measurement scales, like the Richter scale used to measure earthquakes, are based upon a logarithmic scale, which is not linear. Consequently, sound pressure levels from different noise sources cannot be added arithmetically. For example, a 70 dB sound added to another of equal magnitude will equal a sound of 73 dB (not 140 dB). Sound levels are adjusted (or weighted) by the sound meter for the variation in human sensitivity to sound frequencies (higher frequency sensitivity) and are reported as A-weighted decibels (dBA).

Noise levels also vary with time. The statistical noise level method is used to describe the noise environment and time-varying noise levels in this EIS. The statistical noise level method (L_{10}, L_{50}, etc.) describes how often a given sound level is exceeded during the period of the measurement. For example, L_{10} is the noise level that would be exceeded 10 percent of the time; that is, not very often. Conversely, the L_{90} noise level would be exceeded most of the time (90 percent of the time), and would represent the background noise level or low ambient noise levels in the noise environment. Particular, identifiable noise sources are additive to the background noise, forming the total noise environment.

3.7.2. Study Area and Survey Methods

The study area for this analysis was defined to include sensitive receptors that are close enough to the project area to be affected by noise from construction and operation. They include the Paulina and North Cove campgrounds and the top of Paulina Peak. Noise measurements were performed between 1:00 a.m. and 2:30 p.m. on July 25, 1993, by Consultants in Engineering Acoustics, San Francisco, California. Measurement periods varied from 15 to 30 minutes in length at each site.

3.7.3. Existing Conditions

The proposed site is located in a nonurbanized, forested area of varying terrain, including sloping areas and terraces. The project study area is partially disturbed, characterized by logging/access roads and areas which have been logged or have experienced high tree mortality due to a beetle infestation (see Section 3.11, Vegetation). The noise environment at the project site is dominated by natural outdoor sounds, including wind through tree branches and animal activity. Intermittent activities, such as logging, construction, and recreation (snowmobiling, off-road vehicles, aircraft overhead, etc.) can raise these levels significantly for brief periods.

Three sites, representative of the closest recreation facilities in nearby Newberry caldera, are discussed in this analysis. Observation suggests that background noise levels are similar at the Paulina Lake Campground and Lodge, and at the North Cove and Warm Springs Campgrounds. Vehicular and pedestrian traffic and human activities are dominant noise sources at Paulina Lake Campground and Lodge, located on the southwest corner of Paulina Lake. In contrast, North Cove and Warm Springs Campgrounds, located near each other on the north side of Paulina Lake, are accessible only by foot or by boat, and do not appear to be used frequently. Noise here is low, limited to sources from foot traffic, campground activities, and outboard motors (operated quietly so as to conform to boat speed restrictions).

Table 3.7-1 shows average overall sound levels in dBA, measured at the three locations and the octave band spectra, in dB. Ambient noise levels are low within the caldera, even at the noisiest location; in the daytime, they range between 26 and 39 DBA at the various locations. Assuming an absence of insects, background levels at night may be somewhat lower than shown in Table 3.7-1.

Table 3.7-1 Ambient Noise Levels at Three Receptor Locations During Daytime on July 25, 1993

Location	Octave Bank Level - in dB								Average Overall Sound Levels In dBA[1]
	63Hz	125Hz	250Hz	500Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Top of Paulina Peak	41	33	25	21	18[2]	16[2]	16[2]	16[2]	26 dBA[3]
Paulina Lake Campground	54	48	38	35	33	26	24	20[2]	39
North Cove Campground	36	35	27	25	23	19[2]	19[2]	19[2]	29

[1]Averages were calculated from 5 to 8 samples selected from the magnetic tape recordings at each location. The samples were selected to be representative of background at a particular location, and excluded atypical events, nearby traffic in Paulina Campground, for example, or flies buzzing around the microphone at Paulina Peak.
[2]These values are at or near the lower operating limits of the measurement equipment, and should be interpreted cautiously.
[3]Breezes rustling the pines and bird songs, in the absence of people, were dominant on Paulina Peak. Human activities and traffic within the campground and on the Monument Access Road are dominant at Paulina Lake Campground. Breezes in the pines and talking by fishermen in distant boats are dominant at the North Cove Campground.

3.8. LAND USE

3.8.1. Land Ownership

The entire geothermal development project, including transmission line, would be located on Federal lands. The lands immediately surrounding the project area are Federally owned and are under the jurisdiction of the U.S. Forest Service. A few inholdings of private property exist near the alternative transmission line areas toward the western edge of the Forest boundary near LaPine Station. Within the Deschutes National Forest, the Oregon Department of Transportation has an easement for Highway 97. Utility corridors that have rights-of-way through National Forest lands are:

- Bonneville Power Administration
- Midstate Electric Cooperative
- U.S. West Communications
- Pacific Gas and Transmission

Outside the Deschutes National Forest boundary, near Highway 97, land ownership is a patchwork of either Federally owned lands under the jurisdiction of BLM or private lands.

3.8.2. Adopted Land Use Policies

3.8.2.1. Newberry National Volcanic Monument Act (PL 101-522)

The legislation enacted in 1990 that created the NNVM recognizes the geothermal development potential of the region. The Act established a series of land use designations. Figure 3.8-1 highlights the locations of these land use designations. These include the NNVM itself, where no geothermal development of any kind is permitted, and the following management zones:

- Newberry Special Management Areas: perimeter lands on the flanks of the Newberry caldera and adjacent to the Monument boundary that are to be managed as if part of the Monument, with no surface occupancy permitted for geothermal facilities. However, directional drilling from outside the Special Management Area boundaries to subsurface geothermal resources is permitted.

- Transferal Areas: a series of designations that recognize existing geothermal rights and establish provisions for transferring management of the areas to either general public land laws or to the Newberry Special Management Area.

3.8.2.2. Deschutes National Forest Land and Resource Management Plan

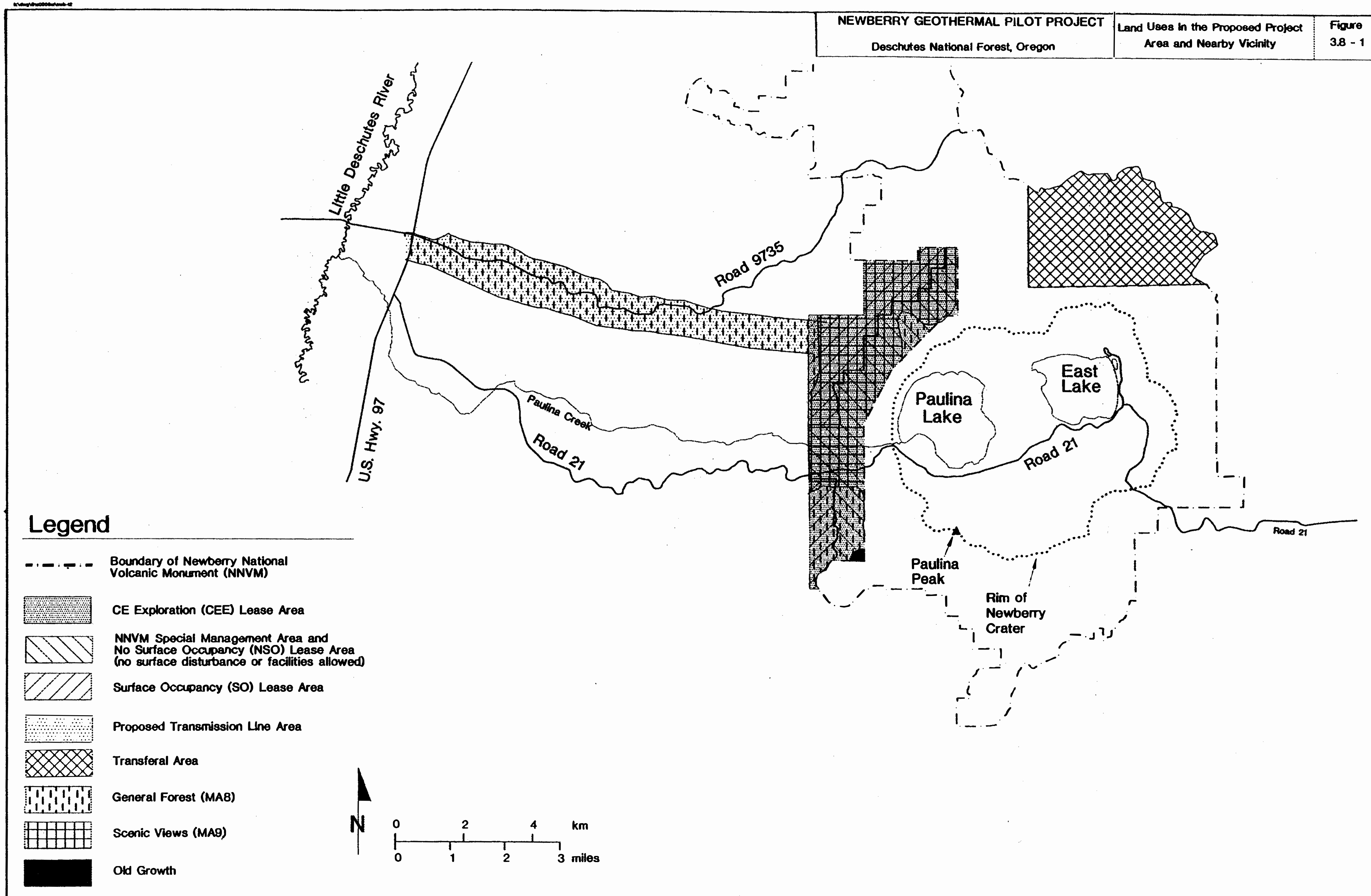
The Deschutes National Forest Land and Resource Management Plan (Forest Plan) was approved in August 1990. The Forest Plan establishes direction for all resource management activities and establishes a system of standards, guidelines, and prescriptions to manage the Forest for a 10 to 15 year period. The goals of the Forest Plan specifically provide for the exploration, development, and utilization of energy resources within the Newberry Caldera Known Geothermal Resource Area (KGRA) where the development of the geothermal resource is compatible with other resource values. Exploration, development, and utilization of lands to produce geothermal energy would have to be in accordance with the objectives prescribed for the Management Area allocation assigned to those lands in the Forest Plan. The pertinent Management Area allocations for the project and their standards and guidelines for geothermal leasing are described below.

Management Area Allocations. The Forest Plan identifies 28 separate Management Areas throughout the forest, each with its own management prescriptions. Management allocations for the project area that guide geothermal leasing and timber harvest activities are shown on Figure 3.8-1 and include:

- General Forest (M8): Timber production is emphasized with unmanaged forest stands converted to managed stands in a variety of age classes. At the same time, areas with this allocation should provide forage production, visual quality, wildlife habitat, and recreation opportunities for public use and enjoyment. Geothermal leases will be issued.

- Scenic Views (M9): Siting of facilities and removal of trees, although permitted for geothermal development, should conform to visual quality objectives such that when seen from travel routes and use areas, activities are either not evident or are visually subordinate to the natural landscape. Geothermal development may be located in this area if the facilities and improvements blend with the characteristic landscape. Visual quality objectives may not always be met when the viewer is at the project site.

Table 4.8-1 lists the relationship between individual project features and Management Area allocations assigned in the Forest Plan.


NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon
Land Uses in the Proposed Project Area and Nearby Vicinity
Figure 3.8 - 1
Little Deschutes River
U.S. Hwy. 97
Road 9735
Paulina Creek
Road 21
Paulina Lake
East Lake
Road 21
Road 21
Paulina Peak
Rim of Newberry Crater
Legend
Boundary of Newberry National Volcanic Monument (NNVM)
CE Exploration (CEE) Lease Area
NNVM Special Management Area and No Surface Occupancy (NSO) Lease Area (no surface disturbance or facilities allowed)
Surface Occupancy (SO) Lease Area
Proposed Transmission Line Area
Transferal Area
General Forest (MA8)
Scenic Views (MA9)
Old Growth
N
0 2 4 km
0 1 2 3 miles

Roadless Areas. The Deschutes National Forest contains 11 areas identified as "roadless" in the Roadless Area Review Evaluation II (RARE II) process. These areas total approximately 58,738 hectares (145,142 acres). The Record of Decision for the Forest Plan (1990) designates nonwilderness, multiple-use allocations for these areas. However, the Forest Plan also specified that no scheduled timber harvests would occur in any roadless area for the first 10 years of the Plan. The term "scheduled timber harvest" means that wood from such harvesting is calculated as part of the Allowable Sale Quantity for the Deschutes National Forest. The roadless areas in the forest have not been developed because they generally contain low value timber. Most of the North and South Paulina Roadless Areas are now within the NNVM.

The North Paulina Roadless Area (RARE No. 06196, shown in Figure 3.9-1), contains 8,750 hectares (21,622 acres) and includes the north rim and flank of Newberry Crater. The North Paulina Roadless Area is bounded on the north by Road 9735 and on the west by a General Forest Management Area allocation. Portions of the project area located in the North Paulina Roadless Area include: the eastern half of Section 16; the northeastern corner of Section 21; and all of Sections 11, 14, 15 and 22 within T21S R12E. These project area lands are within the Scenic View Management Area (M9) allocation of the Forest Plan. This allocation allows geothermal development with the appropriate environmental analysis and stipulations to protect visual quality. The potential for geothermal activity in this area is recognized in the Record of Decision for the Forest Plan (U.S. Department of Agriculture 1990b).

Among the conclusions reached in the Forest Plan about the North Paulina Roadless Area was that its potential for "wilderness" designation was very low. This was in part because the area offers a moderate opportunity for solitude, little opportunity for primitive recreation, few challenging experience opportunities, and is not large enough to adequately buffer outside influences, especially sound generated from developed recreation areas inside the Newberry Caldera.

The South Paulina Roadless Area (RARE No. 06197) contains 4,013 hectares (9,915 acres) and includes the southern rim and flank of Newberry Caldera. A small portion (less than approximately 40 hectares [100 acres]) of the project area is located within the South Paulina Roadless Area. These project area lands are within the General Forest Area (M8) allocation of the Forest Plan. This allocation emphasized timber production with unmanaged forest stands converted to managed stands in a variety of age classes, and allows for issuing geothermal leases.

Paulina Creek: Eligibility as a Wild and Scenic River. Paulina Creek is the only perennial stream in the project area. It originates as outflow from Paulina Lake and flows through the Special Management Area. Approximately 0.8 km (0.5 mile) downstream from Paulina Lake the stream drops over the approximately 300-meter (100-foot) Paulina Falls. The creek then descends at a fairly rapid rate over numerous smaller falls and cascades. Paulina Creek has been determined to be eligible as a Wild and Scenic River (Appendix D-8, Deschutes National Forest Land and Resource Management Plan). However, a suitability study for this designation has yet to be completed. Outstandingly Remarkable Values (ORVs) of the creek that make it eligible for possible inclusion in Wild and Scenic River system include its unique draining of a lake within an expended caldera and its scenic waterfalls. As one of many recreation attractions of the Newberry National Volcanic Monument, Paulina Creek qualifies as a recreational river.

Management of the Paulina Creek corridor from Paulina Lake to McKay Crossing is based on the Wild and Scenic Rivers classification (M19) in the Forest Plan. Essentially, the corridor is managed in a manner that will not detract from its eligibility as a Wild and Scenic River. At a minimum, this means meeting the standards for recreational sections of the Wild and Scenic Rivers Act as set forth in the Forest Plan. The proposed project does not cross or otherwise affect Paulina Creek.

The Recreation Experience and Recreation Opportunity Spectrum Allocations. The U.S. Forest Service manages for a variety of recreational opportunities and experiences using the Recreation Opportunity Spectrum (ROS). The ROS provides a framework for defining the types of outdoor recreation opportunities the public might desire and identifies that portion of the spectrum a given forest area might be able to provide. The ROS classifications are an inventory, and do not provide management direction for this area.

The ROS allocations for the project area are Roaded Modified and Semi-Primitive Motorized (winter only). Table 4.8-1 lists the relationship between individual project features and the ROS allocations. Outside the project area, the Paulina Creek/Road 21 Corridor and McKay Butte have a Roaded Natural allocation. A Roaded Natural allocation predominates around Paulina and East Lakes, and for Paulina Peak. Areas around the resorts and campgrounds are classified as rural. Use of the ROS and characteristics of the pertinent ROS classifications within the project vicinity are defined in the Glossary.

3.8.2.3. Oregon Department of Energy, Energy Facility Siting Council (EFSC)

The EFSC has designated the project area as suitable for power plant siting with the need to retain the visual character of the area.

3.8.2.4. Deschutes County Year 2000 Comprehensive Plan

The Deschutes County Year 2000 Comprehensive Plan recognizes the Deschutes National Forest Land Management Plan as the determining document for land use decisions regarding Federal lands within the forest. However, the U.S. Forest Service and the Deschutes County Planning Department have a Memorandum of Understanding that establishes procedures for complying with the Deschutes County Year 2000 Plan.

3.8.3. Newberry National Volcanic Monument Management Plan

The Newberry National Volcanic Monument (NNVM) is adjacent to the eastern boundary of the project area and is approximately 1.6 km (1 mile) east of the proposed power plant site. The NNVM Act requires the U.S. Forest Service to prepare a comprehensive Management Plan for the Monument and the Newberry Special Management Areas. That plan, and an EIS for the plan are being conducted concurrently with the preparation of this EIS. Lands immediately adjacent to the north and east of the project area have been categorized as a Flanks Zone in the three broad management alternatives being developed by the U.S. Forest Service for the Monument. The Special Management Areas designated in the Monument Act are wholly contained within the Flanks Zone. The NNVM Comprehensive Management Plan EIS recognizes this geothermal pilot project proposal, and on-going coordination is taking place between the two planning processes.

3.8.4. Existing Land Uses and Facilities

Present land uses in the immediate project area include commercial forestry, fuelwood gathering, and dispersed recreation. Figure 3.9-1 illustrates the developed recreation facilities near the project area. Recreation visitation to the Deschutes National Forest and the NNVM is increasing. This is in part due to creation of the NNVM; recent improvements to Road 21; general population growth in the state and region; and overall outdoor recreation trends in dispersed recreation, most notably snowmobiling, Nordic skiing, and mountain biking (Oregon State Parks and Recreation Division 1989).

3.8.4.1. General Forestry

Recently logged units and the Fishhook LP Salvage Sale are illustrated on Figure 3.8-2. The Fishhook LP Salvage Sale, scheduled to be completed in December 1994, is predominantly a cut of areas of forest that have been infested by the mountain pine beetle. Harvest actions are required to leave dominant seed trees at a spacing of 12 to 26 meters (40 feet to 85 feet). Trees under 12.7 cm (5 inches) diameter will not be harvested. Wildlife snags and dispersed clumps of vegetation a minimum of 0.4 hectare (1 acre) in size will be left standing in all units.

Another timber sale, the Prairie Dog Sale, has been programmed for the general area south of Road 21. The sale boundary encompasses the portion of the project area that includes well pads L4 and M4. However, no detailed harvest units have been identified at this time.

3.8.4.2. Fuelwood Gathering

Fuelwood gathering has been permitted throughout the project area as part of the Fort Rock District's fuelwood program. Within the Scenic Views Management Area (M9), fuelwood gathering is managed to be consistent with the desired visual condition of Retention in the lodgepole forest association.

3.9. RECREATION

Central Oregon offers a diverse range of recreational opportunities. Deschutes County is recognized as one of the most important recreation centers in Oregon, with over 90 percent of all visitation to the area originating from outside the county (ECO Northwest 1989). Deschutes County has experienced an average 4.7 percent annual population growth over the past 5 years. This rate of growth is projected to continue into the foreseeable future. This growth creates demands for day-use recreation on National Forest lands.

Outdoor recreation use in the project area is increasing. Statewide demand for primitive, semi-primitive, and roaded natural recreational experiences in central Oregon is increasing (Oregon State Parks And Recreation Division 1988) and is outpacing the supply of additional facilities (Oregon State Parks And Recreation Division 1991). Growth in actual visitor use demonstrates this pressure for additional recreation areas and facilities. For example, the Lava Lands Visitor Center has shown a 35 percent increase in the number of visitors since 1988. In 1986, the number of cars that entered the Newberry Caldera totaled 51,341. In 1992, this number had increased to 64, 936 (Deschutes National Forest).

Table 3.9-1 presents existing visitor use information for the selected developed and dispersed recreation areas within the NNVM.

3.9.1. Access

U.S. Highway 97 and County/U.S. Forest Road 21 are the major recreation access routes in the project vicinity. The Highway 97 corridor is a main north-south route through central Oregon, bisecting the northern portion of the NNVM. The number of travelers on this road has steadily increased over the past 20 years. Highway 97 is also the spine that links other access roads to the various destination points within the NNVM. Road 21 runs east from Highway 97 through the caldera in the southern portion of the NNVM. Road 21 has recently been upgraded to improve access to the caldera and to accommodate projected increases in recreation use. Other roads used for general recreation access within the project area include Roads 9725, 9735, 2120, 9737, and 2121. Road 9735 is also a recreation travel route, and provides the most direct access to the lease areas north of Paulina Creek. Road 9735 has been reconstructed to a hard rock surface recently to accommodate log hauling.

Currently Road 21 is the only winter access route leading to the project area. It is not plowed beyond 10-Mile Snowpark and is gated at that point during winter.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Existing & Proposed Logging Units in the Study Area	Figure 3.8 - 2

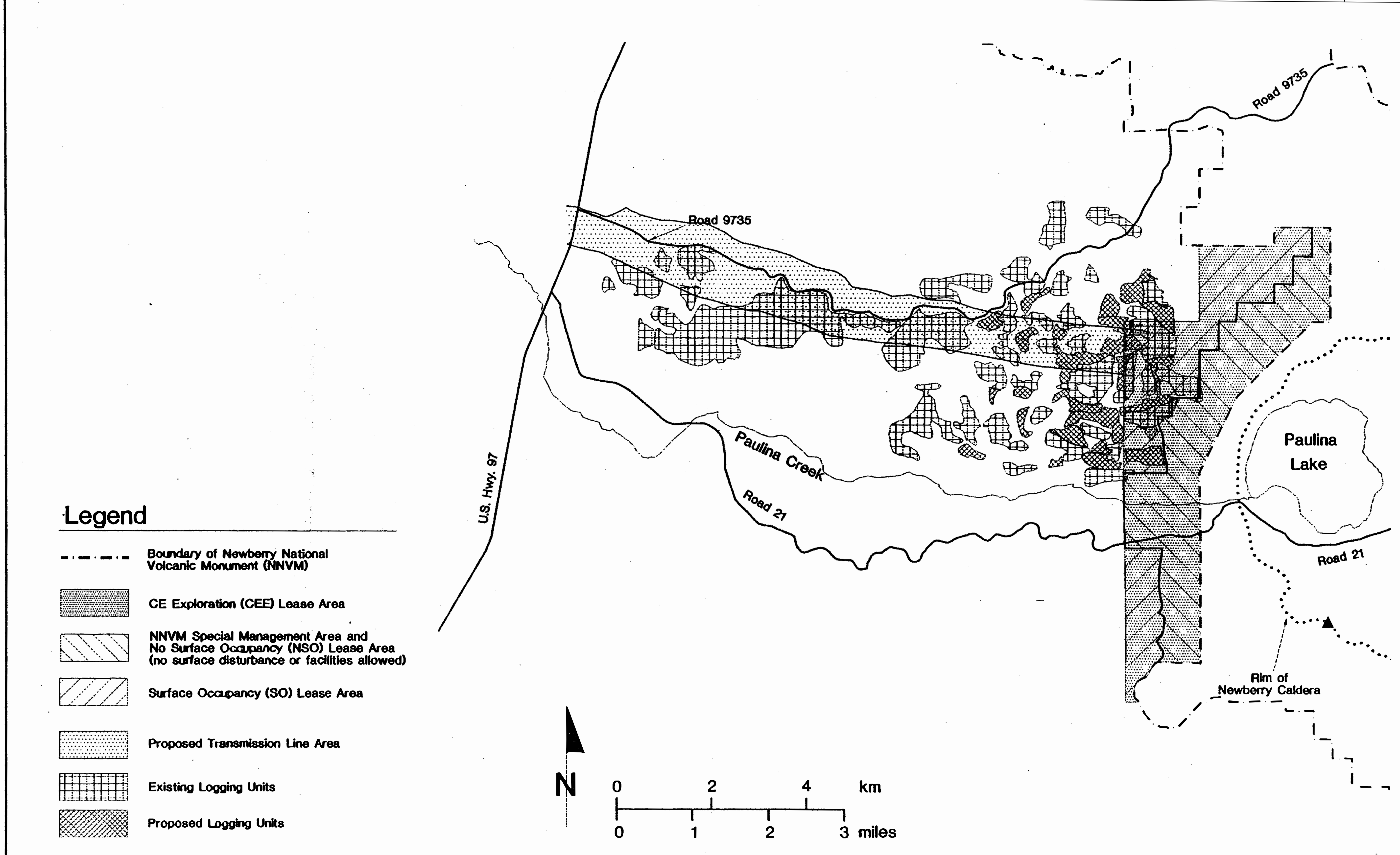


Table 3.9-1 Use at Newberry National Volcanic Monument (in Recreation Visitor Days)*

	Feature	1992 Use Estimates	% of Total Use
Developed Recreation	Paulina Peak Viewpoint	6,109	1.8
	Paulina Creek Falls	2,630	0.8
	Other Developed Caldera Facilities	99,181	29.5
	Subtotal Caldera Areas	**107,920**	**32.1**
	Lava Cast Forest	11,212	3.3
	Lava River Cave	7,104	2.1
	Benham Falls	4,293	7.2
	Lava Lands Visitor Center	37,750	11.2
	Lava Butte Visitor Center	48,019	14.2
	Subtotal Non-Caldera Areas	**128,378**	**38.0**
Dispersed Recreation	Newberry Caldera (lakes and trails)	87,563	26.0
	Within the Monument but outside Caldera	13,314	3.9
	Subtotal Dispersed Use	**100,877**	**29.9**
TOTAL		**337,175**	**100.0**

* *Source: Deschutes National Forest PRIS data.*

3.9.2. Developed Recreation Sites, Trails and Dispersed Recreation

Table 3.9-2 provides a summary description of the developed recreation sites near the project area. Newberry Caldera is a major recreation destination and regional tourist attraction. It is an all-year recreation area providing a full complement of day-use and overnight facilities. Fishing on Paulina and East Lakes is the primary attraction with camping, boating, nature observation, hiking, biking, and horse camping also being popular. Winter activities are predominated by snowmobiling. Nordic skiing, while gaining in popularity in the caldera, attracts much smaller numbers than snowmobiling. Winter activities are supported by the 6-Mile and 10-Mile Snowparks and complemented with the winter operations of Paulina Lake Lodge. The 10-Mile Snowpark is the primary trail head for Nordic skiers.

Generally, the immediate area where project facilities would be developed receives little, if any, recreation use in the summer months. However, more dispersed recreation takes place east of the project area and generally within close proximity to roads, trails, and other access points. Dispersed camping occurs near edges of lava flows, within close proximity of roads and trails, and near water sources. Horse use in the project area generally begins at the Peter Skene Ogden trailhead. Figure 3.9-1 shows trails and dispersed recreation destinations that are within or near the project area.

In general, dispersed recreation use near the project area is increasing. Table 3.9-3 overviews the trails within and adjacent to the project area. Quantitative data about dispersed recreation activities and patterns of use are not available; however, some patterns of use are understood. Table 3.9-3 also overviews the permitted uses and provides a general characterization, by trail, about the existing relative levels of each use.

Table 3.9-2 Developed Recreation Sites Within and Adjacent to the Project Area

Feature	Generalized Characteristics
Newberry National Volcanic Monument / Newberry Caldera	Intensive recreational use area with the following facilities in the occupancy zone adjacent to Paulina and East Lakes: - 9 boat ramps - 6 picnic sites - 5 general-use campgrounds (300 sites) - 1 horse camp (14 sites) - 2 hike in/boat-in campgrounds (11 sites) - 1 group campground (3 sites) - 6 recreation residences - 2 private resorts - 1 private RV park
Newberry National Volcanic Monument/Lava Cast Forest	- picnic area - 1-mile long interpretive trail
Ogden Group Campground	- group camp
McKay Crossing Campground	- 10 sites
Prairie Campground	- 14 sites
10-Mile Snowpark	- Parking/staging area
6-Mile Snowpark	- Parking/staging area

There are approximately 24.1 km (15 miles) of summer-use trails north of Paulina Creek and within the North Paulina Roadless Area. All trails are closed to motorized vehicle use. These include the Newberry Crater Rim loop trail, the Swamp Wells trail, and the Paulina Lake loop trail. The Peter Skene Ogden National Recreation Trail parallels Paulina Creek on its north side and extends from Paulina Lake to the trailhead and equestrian staging area near the Ogden Group Campground. Away from Paulina and East Lakes, Paulina Falls and Paulina Peak are popular destination points for summer trail users.

A few hunting camps have been established along U.S. Forest Service Roads 9735 and 2121 with hunting likely occurring in the project area. Bow hunting activities occur in August and September. Deer hunting is permitted from the last week in September into the first two weeks of October. Elk hunting is permitted on two 4-day periods in November. During these times as many as 5,000 to 10,000 hunters visit the flanks of the Newberry Caldera. Hunting is not permitted within the Caldera boundary, as it is a designated wildlife refuge.

A 4.8-km (3-mile) nordic trail leading to Paulina Lake Lodge originates at the 10-Mile Snowpark. Approximately 241.4 km (150 miles) of snowmobile trails are maintained in and around the Newberry Caldera. All snowmobile trails, however, can be used by nordic skiers as they are dual-use trails. Snowmobile Trail No. 64 travels north from Paulina Lake Lodge and passes through the project area. Snowmobile Trail No. 2 parallels Road 2121 and passes through the project area south of Paulina Creek. In both cases, snow play areas exist along or near the trail, typically in recent timber harvest areas.

Popular snowmobile destinations include Paulina Falls, Paulina Lake and Lodge, North Paulina Peak and, when weather permits, Paulina Peak. The pumice flats and bowls on the rim and in the vicinity of North Paulina Peak are popular play areas for snowmobiling. These areas, and the trails leading to them, receive the bulk of snowmobile use north of Paulina Lake.

NEWBERRY GEOTHERMAL PILOT PROJECT

Deschutes National Forest, Oregon

Selected Recreation Features in the Project Vicinity

Figure 3.9 - 1

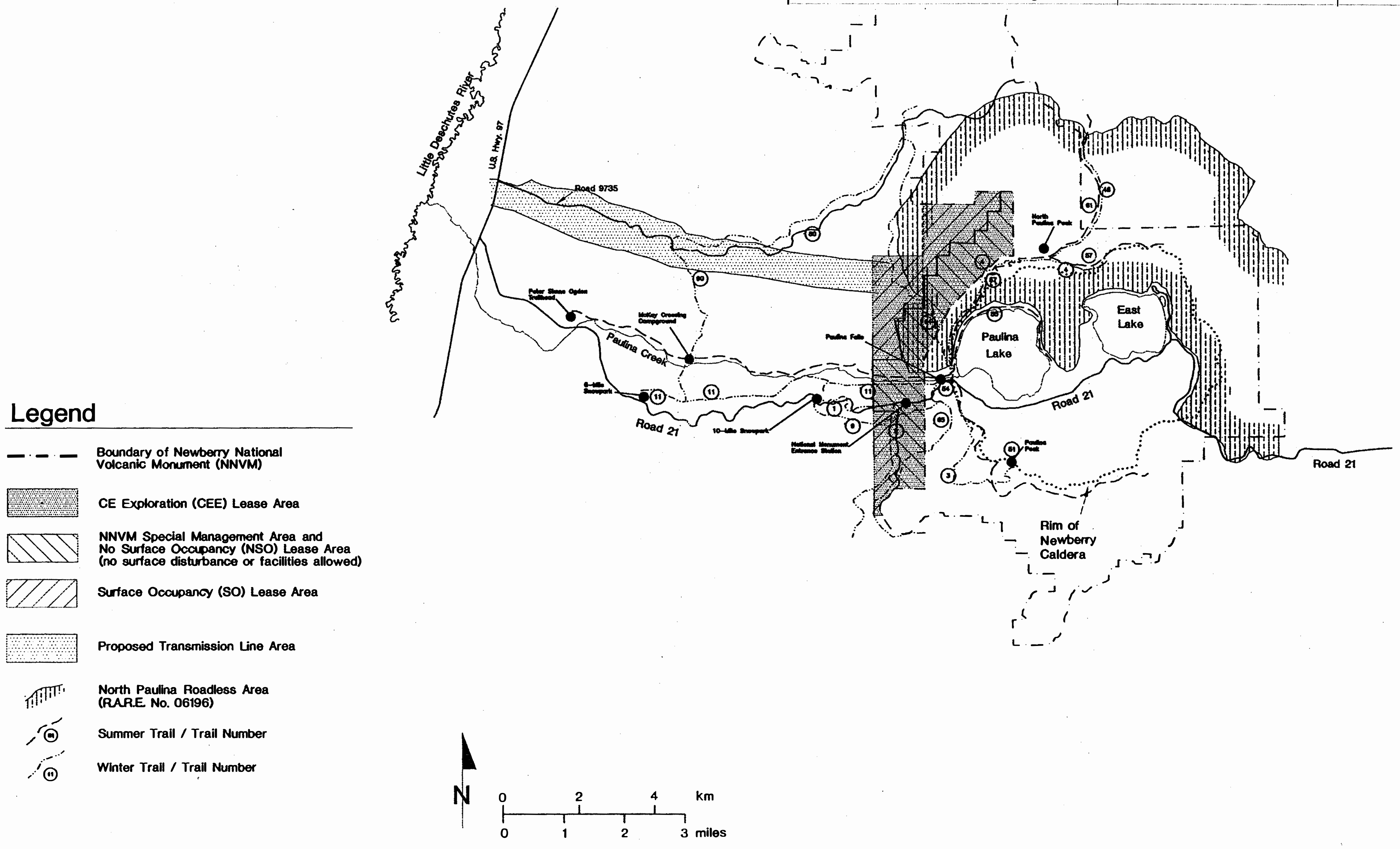


TABLE 3.9-3
Selected Trails Through and Near the Project Area[1]

		Permitted Uses/Relative Use Estimates				
Trail Number	**Trail Name**	**Horse/Pack Animal**	**Mountain Bike**	**Hiking**	**Snowmobile**	**Nordic**
No. 51	Paulina Peak Trail	Closed	Closed	Open / Heavy		
Winter No. 3	Paulina Peak Road	Closed			Open / Heavy	Open / Heavy
No. 54	Paulina Falls Trail	Closed	Closed	Open/Heavy	Closed	Not Designated / Light
Winter No. 11[2]	Power Line Trail Spur				Open / Heavy	
No. 55	Paulina Lake Loop	Closed	Closed	Open / Mod.	Closed	Not Designated / Light
No. 56	Peter Skene Ogden National Recreation Trail	Open / Moderate	Open / Heavy uphill only	Open / Heavy	Closed	Not Designated / Light
No. 57 Winter No. 4	Newberry Crater Rim Loop Trail	Open / Mod.	Open / Mod.	Open / Light	Open / Mod.	Open / Light
No. 61	Swamp Wells Trail	Open / Light	Open / Light	Open / Light	Open / Light	
Winter No. 48	Swamp Wells Trail	Open / Light	Open / Light	Open / Light	Open / Heavy	Open / Light
Winter No. 11	Power Line Trail				Open / Heavy	Open / Mod.
Winter No. 2	South End Loop Trail				Open / Heavy	Open / Mod.
Winter No. 64	Northwest Area Trail				Open / Heavy	Open / Light
Winter No. 65	Cutoff Trail for South Loop				Open / Heavy	Open / Mod.
Winter No. 80/90	Forest Roads #9735 / #9736				Open / Mod. to Heavy	Open / Light

[1] Source: Deschutes National Forest/2M Associates
[2] Spur Trail from Winter Trail #11 (the Power Line Trail) to Falls Overlook

3.9.3. Concessions and Commercial Permits

Principal concession operations and commercial permits associated with recreation at the Newberry Caldera include: Paulina Lake Lodge; East Lake Lodge; boat rentals; guided snowmobile tours of the Monument; snowmobile rentals; and horseback and pack trips that start from the Peter Skene Ogden Trailhead.

3.10. TRAFFIC AND TRANSPORTATION

3.10.1. Study Area

The study area for this traffic and transportation analysis is equivalent to the project vicinity, including Highway 97.

3.10.2. Regional Setting

Many roads provide access to the Newberry Volcano area (Figure 3.10-1). Principal access to the NNVM is described in Section 3.9.1, Recreation. Both Highway 97 and Road 21 are double-lane, paved, and meet Highway Safety Act standards for signing and traffic controls.

The U.S. Forest Service maintains numerous roads for recreation opportunities, forest management, and commercial use.

Road 9735 is a 1.5-lane, hard rock-surfaced road that would be the main route to the project area. It has a high-quality junction with Highway 97, with flat grades and good visibility opportunities, although there is no formal left turn lane from the highway. The road extends east from Highway 97 about 16 km (10 miles) to the NNVM boundary. For the next 5 km (3 miles), Road 9735 narrows to a single-lane road that crosses the Lava Cascade flow and terminates at Road 9710. Roads 500 and 600 off of 9735 would provide access to well pads and the power plant, with some construction.

Within the NNVM and Special Management Areas are about 100 km (62 miles) of native surface roads, 26 km (16 miles) of aggregate/cinder surfaced roads, and 27 km (17 miles) of paved roads (including Highway 97). The number of km (miles) of roads per square meter (square mile) of area is referred to as the road density. The overall road density for the entire NNVM is 1.6 km/2.5 square km (1.0 mile/square mile).

In late fall, the snowgate above the 10-Mile Sno-Park on Road 21 (see Section 3.9, Figure 3.9-1) is closed and most main roads in and around the caldera are converted to winter recreation trails. Road 21 is the only road access to the NNVM that is regularly plowed.

3.10.3. Traffic Volumes

A number of roads within and with access to the study area have electronic traffic counters to monitor use, although not all counters are monitored every year. If counts are taken for an entire year, the total count is divided by 365 days to yield the Average Daily Traffic (ADT). If counts were taken for only a portion of the year, normally April through September or October, the total vehicle count would be divided by the number of days in the counting period to yield the Seasonal Average Daily Traffic (SADT). For comparison purposes, an ADT of at least 200 is normally used as the threshold for considering a double-lane road.

Data prepared by the U.S. Forest Service (April 1993) from 1991 traffic counts yielded the following results. Road 21 had an ADT of 327 vehicles. This represents a 12 percent increase from 1990 (293 ADT) and a 45 percent increase from 1988 (226 ADT). Part of this increase can be attributed to improvements in the road surface and the designation of the area as a National

Monument. Road 9710, which flanks the northeast side of the NNVM, had a SADT of 33. Road 9720 to the Lava Cast Forest had a SADT of 91. No previous data are available for Roads 9710 or 9720. The last recorded data for Road 9735 was 1985, with a SADT of 57. This is a 33 percent increase over the previous year and a 128 percent increase over 1982.

Traffic counts on Road 21 are higher on weekends than weekdays, and are highest on Sundays. Historically, the highest use in the summer occurs in the second or third week of July. The weather, fishing success, fires or fire closures, and other factors can influence the traffic counts. With the exception of the main recreation routes (including County Road 21 and Road 9720), most roads traditionally receive their most concentrated overall use during the deer hunting season in late September and early October.

The most recent data for Highway 97 located 0.2 km (0.1 mile) south of FS Road 21 (at milepost 161.76) are for 1991. During that year, Highway 97 had an ADT of 8,100 vehicles. In 1990, Highway 97 had an ADT of 7,900 vehicles (Oregon Department of Transportation 1991; 1992).

3.11. VEGETATION

3.11.1. Study Area

The study area for the vegetation analysis was generally defined as the project area for purposes of defining basic vegetative cover types. This includes the transmission line and access road as well as the lease area, including the surface occupancy area and those portions of the 16-hectare (40-acre) siting blocks that fell within the no surface occupancy area.

Several factors have contributed to the distribution of vegetation within the study area. The main factor is volcanic activity which defines soil types located in the study area effectively limiting existing plant associations. Many stands of lodgepole pine in all but the highest elevation parts of the study area (below approximately 2,130 meters [about 7,000 feet]) have suffered considerable mortality due to infestation by the mountain pine beetle (Dendroctonus ponderosae). Dense (overstocked) and older lodgepole stands are highly susceptible to mountain pine beetle infestation. This situation is partially a symptom of an extended state-wide drought which has stressed trees throughout the study area and surrounding forests. A history of fire suppression, drought, beetle infestation, and logging have substantially altered the vegetation in the study area. Satellite imagery from August of 1992 shows that an estimated 50 percent of the study area had been commercially harvested (Figure 3.11-1). The vegetation in the study area is relatively homogenous and typical of the vast forests surrounding Newberry Caldera with a few exceptions in the eastern portion of the lease area where larger, mature, and old growth mixed conifer stands occur.

3.11.2. Vegetation Cover Types

The study area supports forest vegetation of mostly lodgepole pine (Pinus contorta) and ponderosa pine (Pinus ponderosa). Vegetation inventory data were obtained by High Desert Ecology (Linstedt 1993) and cover mapping and characterization was provided by Wildlife Dynamics (Smith 1993).

A total of eight vegetation cover types were identified and mapped within the study area (Figures 3.11-2, 3.11-3, and 3.11-4). This description is divided to cover two basic parts of the project area: the lease area (power plant and well pad sites) located in the eastern part of the study area and the transmission line area which extends westward from the power plant vicinity to Highway 97.

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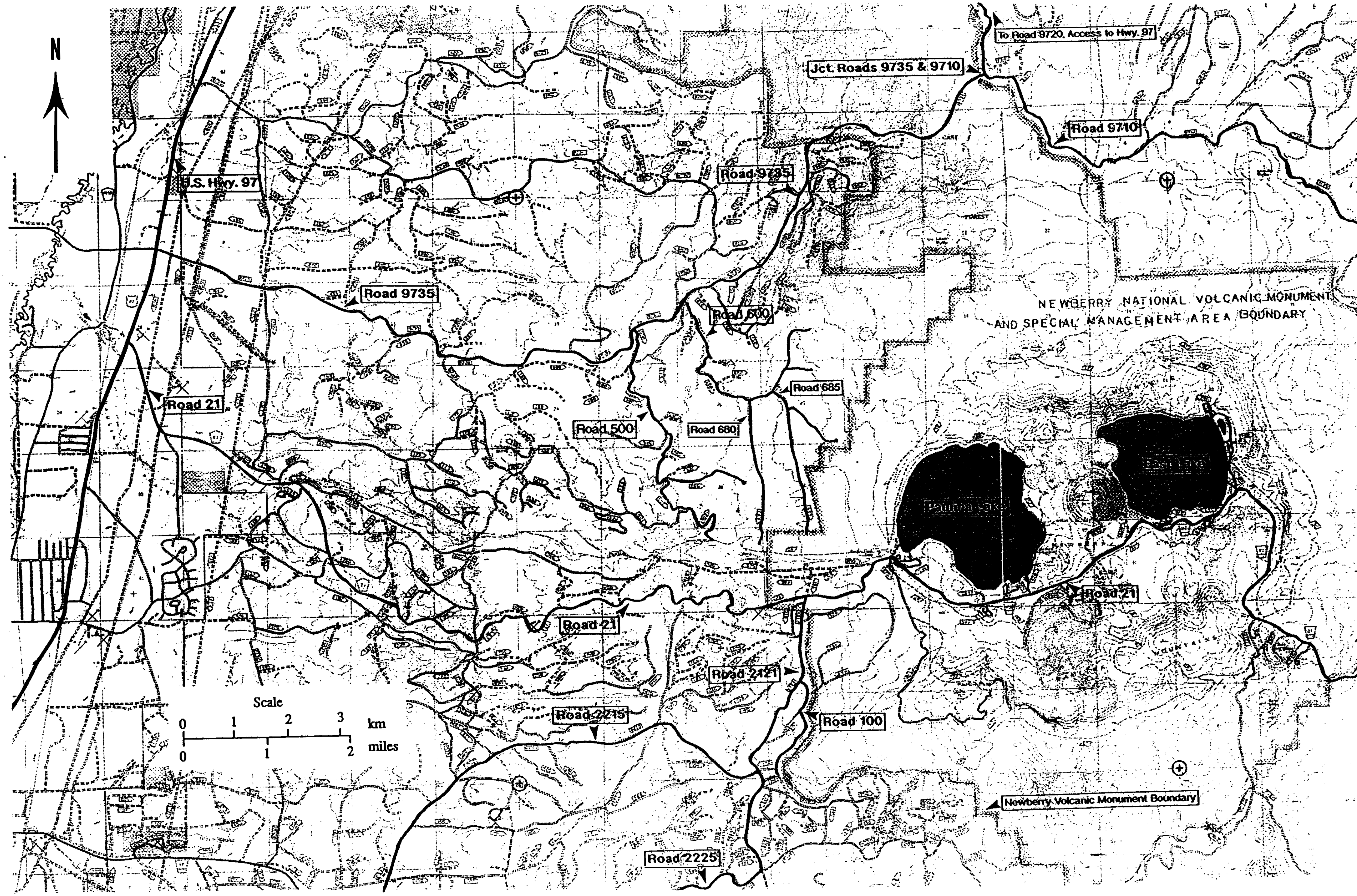
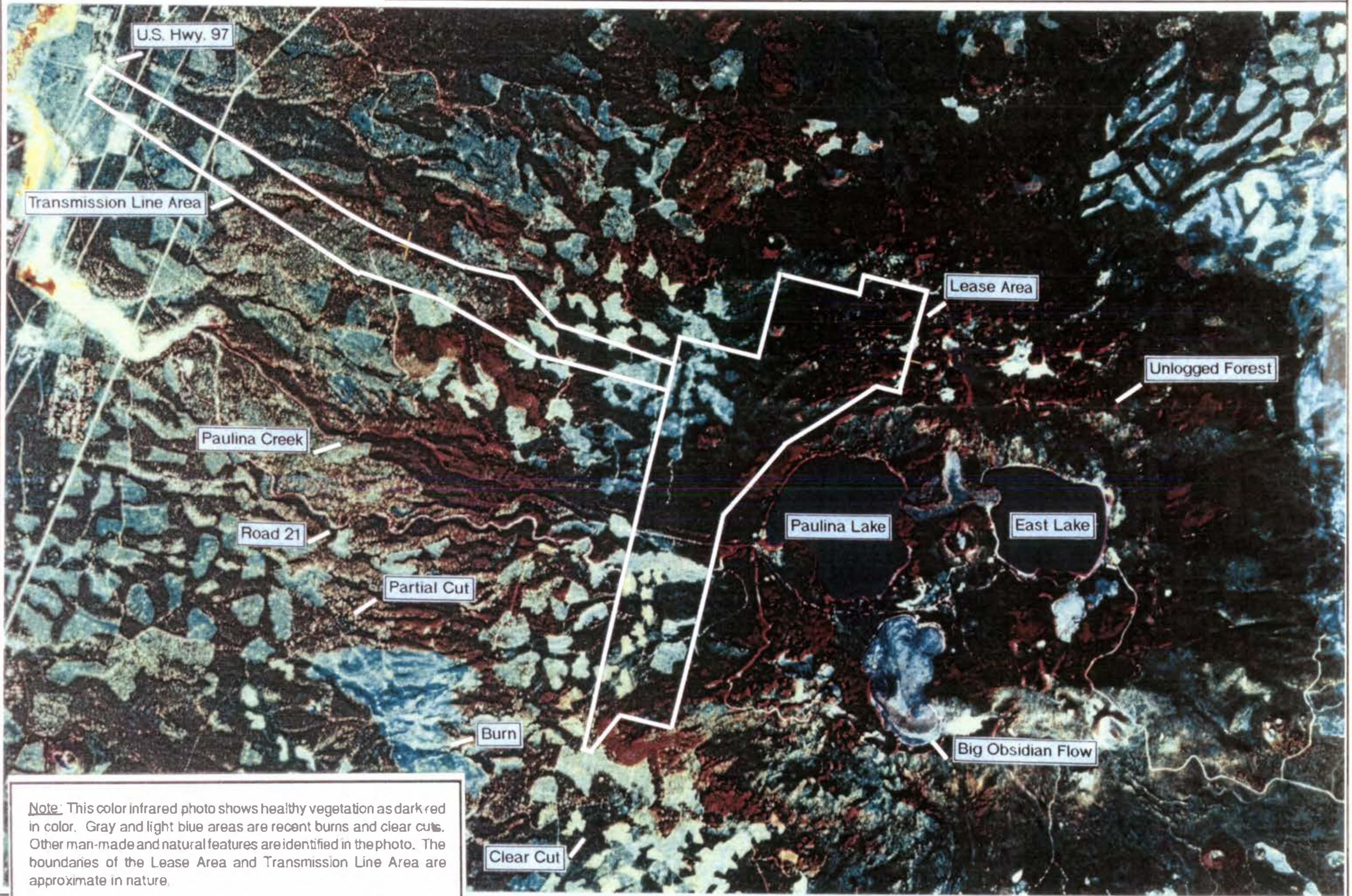
NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

Roads in the Project Area and Nearby Vicinity

Figure 3.10-1



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Regional Context and Vegetation of the Project Area and Nearby Vicinity Source: NASA satellite photo (August 29, 1992)	Figure 3.11-1



Note: This color infrared photo shows healthy vegetation as dark red in color. Gray and light blue areas are recent burns and clear cuts. Other man-made and natural features are identified in the photo. The boundaries of the Lease Area and Transmission Line Area are approximate in nature.

There also exists a community of fruitose, foliose, and crustose lichens. The most dominant foliose lichens include Platismatia glauca, Zethana vulpina, Hypozymnia rugosa, Bryoria abbreviata, Bryoria capillaries, Alectonia sarmentosa, and Cladonia fimbriata. These species prefer old growth (150 year plus) conifer as hosts. Older conifer stands are generally located in the lodgepole pine (LP), lodgepole/mixed conifer (LP-CC), mixed conifer (MC) vegetative cover types that are described more fully below. Lichens are long-lived plants that obtain their nutrients and minerals from direct absorption of chemicals from the air and water deposited on them. As such, they make excellent air quality indicators.

3.11.2.1. Lease Area

The lodgepole pine regeneration (CC in Figures 3.11-2 through 3.11-4) type is a recent clearcut with young planted trees between 0.6 and 2.7 meters (2 to 9 feet) tall with approximately 50 percent canopy. This compromises about 10 percent of the lease area.

The lodgepole pine seed tree (LPCC) type consists of areas that were clearcut or seed-tree regeneration cuts that occurred within the last 3 or 4 years which have not been replanted. Both the clearcut and regeneration cut areas have the appearance of recent clearcuts as generally only a few trees were left and many of those were small and blew down during last winter's (1992-1993) heavy snows. Regeneration in these stands consists of lodgepole pine, 0.3 to 1.4 meters (1 to 4 feet) tall in a clumped and scattered distribution. Standing green trees are small in diameter (7.6 to 15.2 cm [3 to 6 inches]). About 12 percent of the lease area is LPCC.

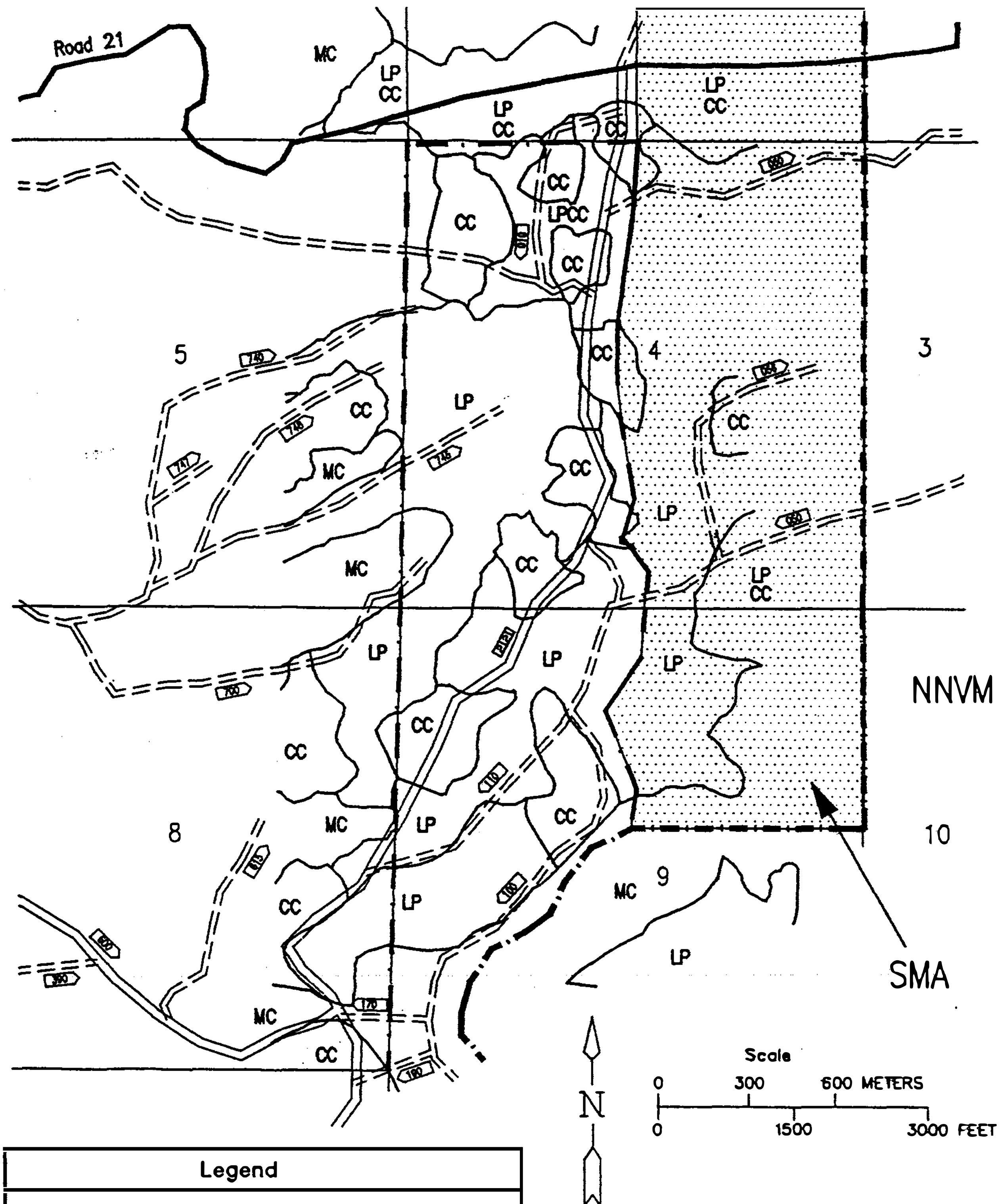
The lodgepole pine (LP) type is unlogged and consists of mature forest of almost pure lodgepole pine. The understory is very sparse and a variable and sometimes large proportion of the trees are dead. This type makes up 58 percent of the lease area.

The lodgepole mixed conifer (LP-MC) type is uncommon (approximately 10 percent of lease area) and is located in the upper portion of the northern lease area. It consists of mature lodgepole pine (about 90 percent of the canopy) with scattered mountain hemlock (Tsuga heterophylla) and western white pine (Pinus monticola). Hemlock is generally located in the subcanopy and the shrub layer. This vegetation type contains small areas of open pumice flats and rock outcrops. One area within this type has a more open canopy. It is located along a south-facing slope at the southern edges of Sections 10 and 11, where meadow areas of dense sedge and some grasses and forbs are present.

The higher elevation lodgepole-dominated and mixed conifer forests of the lease area typically have very sparse understory vegetation. The most common understory species are western needlegrass (Stipa occidentalis), Ross sedge (Carex rossii), bottlebrush squirreltail (Sitanion hystrix), tail-cup lupine (Lupinus caudatus), linanthastrum (Linanthastrum nutallii), broadleaf strawberry (Fragaria virginiana), woodland pinedrops (Pterospra andromedea), sticky currant (Ribes viscossimum), and wax currant (Ribes cereum).

The mixed conifer (MC) vegetation type is unlogged forest with variable canopy closure and understory. It is the most variable type in terms of tree species composition and is widely distributed throughout the study area, occurring from the lowest elevations on the west to the highest elevations on the east. Higher elevation stands tend to be lodgepole dominated by an admixture of white fir (Abies concolor), and/or mountain hemlock, and/or western white pine. Forests of this vegetation type in this part of the study area are mature and unlogged with slightiy higher tree species diversity and a tendency for trees to be larger than most of the rest of the project area (up to 46 to 102 cm [18 to 40 inches] dbh). A total of about 4 percent of the lease area is MC.

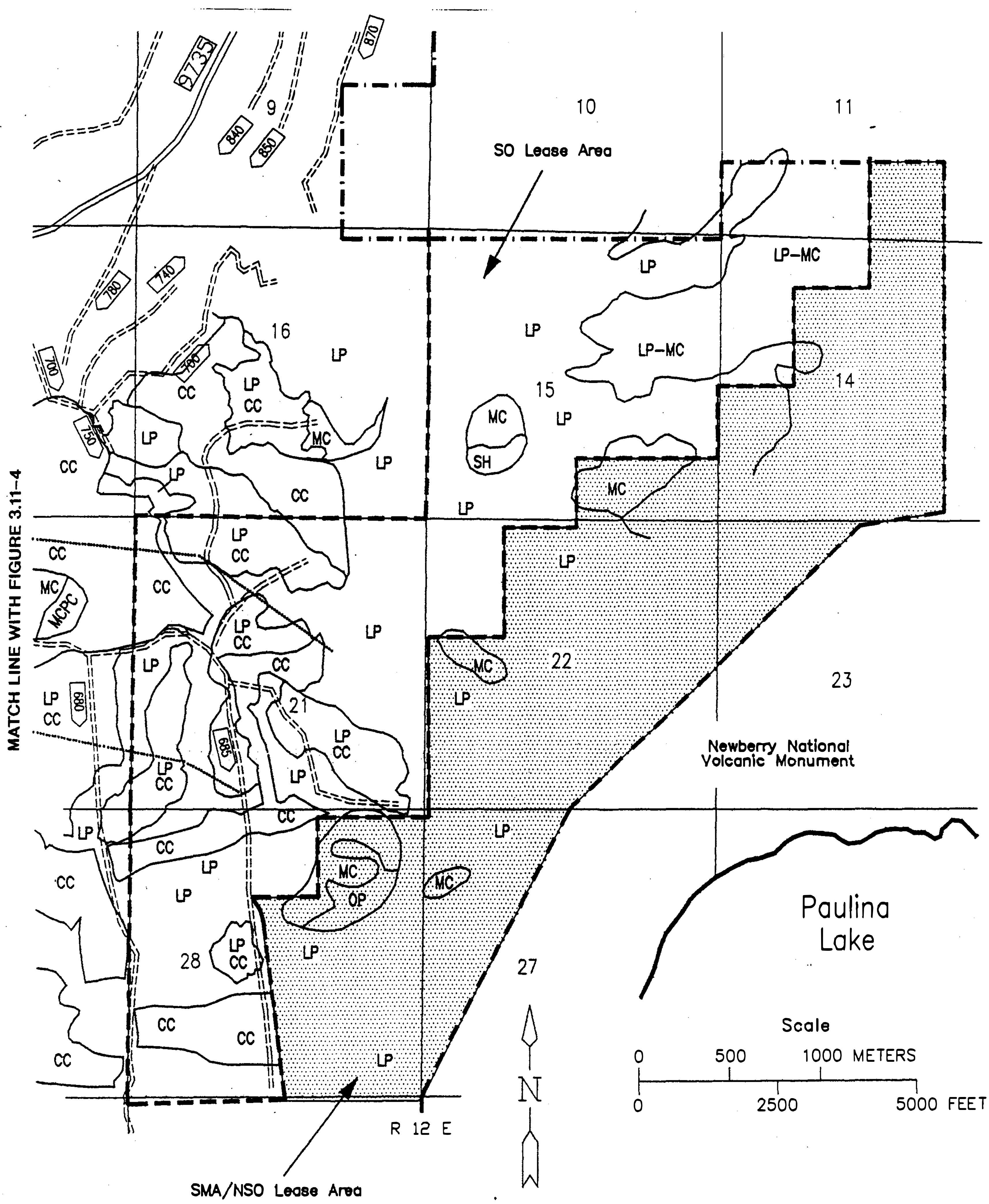
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Vegetative Cover Types in the Vicinity of the Southern Lease Area	Figure 3.11-2



Legend

- Newberry National Volcanic Monument (NNVM) Boundary
- Wildlife Study Area and Boundary of SO Lease Area
- CC – Lodgepole Pine Regeneration
- LPCC – Lodgepole Pine, Seed Tree Type
- LP – Lodgepole Pine
- MC – Mixed Conifer
- Special Management Area (SMA) and NSO Lease Area

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Vegetative Cover Types in the Vicinity of the Northern Lease Area	Figure 3.11-3



Legend

- Newberry National Volcanic Monument (NNVM) Boundary
- Wildlife Study Area and Boundary of SO Lease Area
- Proposed Transmission Line Area Boundary
- SH – Shrub, Rock & Scattered Pine
- CC – Lodgepole Pine Regeneration
- LPCC – Lodgepole Pine, Seed Tree Type
- LP – Lodgepole Pine
- LP–MC – Lodgepole Dominated with Mt. Hemlock & White Pine
- MC – Mixed Conifer
- MCPC – Mixed Conifer, Partial Cut
- OP – Open Ponderosa Pine
- Special Management Area (SMA) and NSO Lease Area

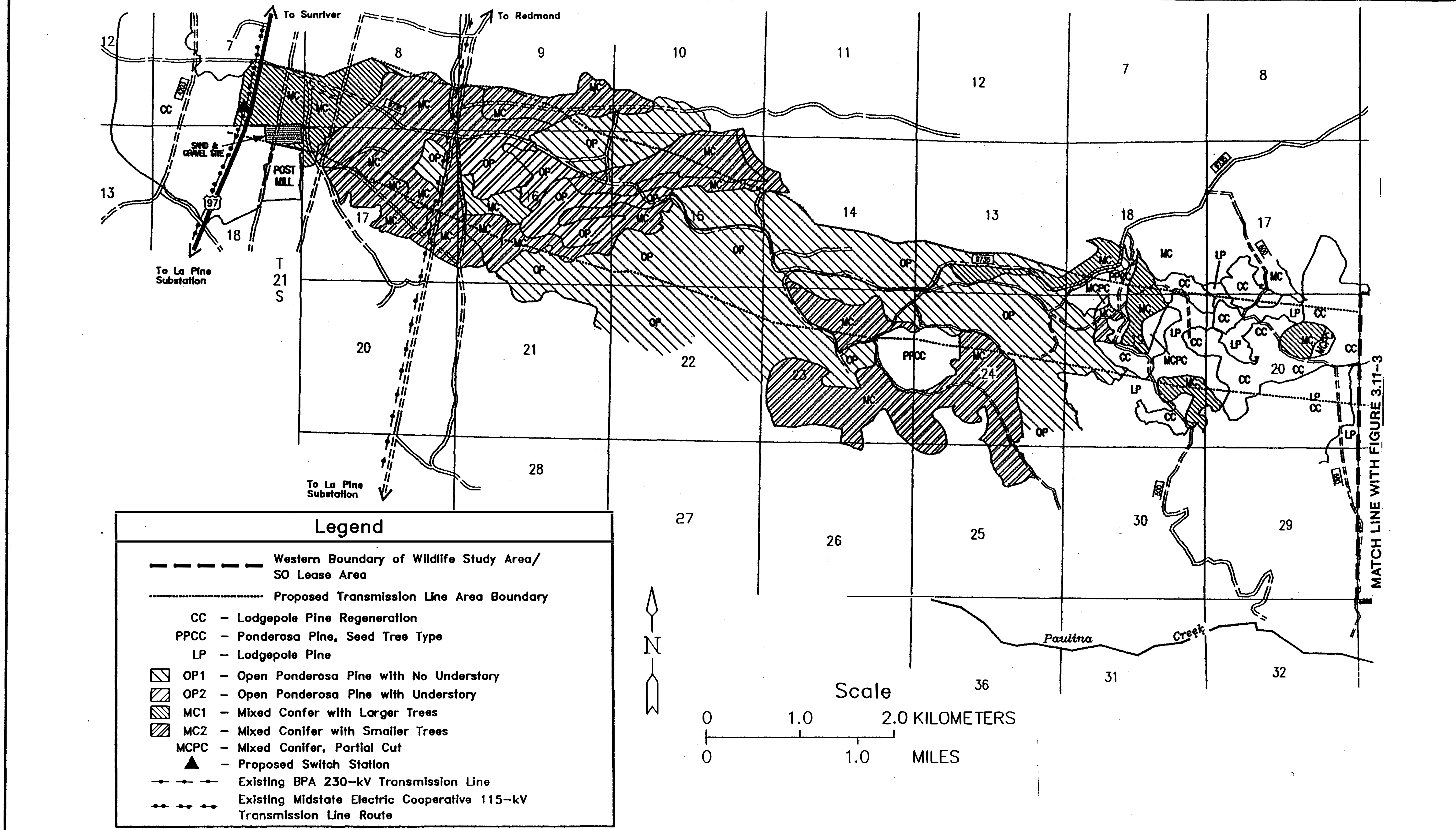
NOTE:

The CE Exploration Lease Area consists of the surface occupancy (SO) lease area and the no surface occupancy (NSO) Special Management Area, in which surface activity is not permitted.

NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

Vegetative Cover Types in the Vicinity of the Proposed Transmission Line Area

Figure 3.11-4



Open ponderosa pine (OP) is present in one small stand within the Special Management Area. It consists of large, old trees with an open canopy, located on the side of a small cinder cone. Little understory vegetation is present and what does exist is similar to that found elsewhere in MC and LP vegetation types. This vegetation cover type is relatively scarce within the project vicinity, comprising about 1 percent of the lease area.

The shrub, rock and scattered pine (SH) type consists of a very small area of manzanita-dominated habitat with scattered ponderosa pine located on a rock outcrop on the fairly steep south-facing slope of a cinder cone in the northeastern portion of the lease area (Figure 3.11-3). Only 0.5 percent of the lease area is SH.

In addition to these communities, a narrow zone of riparian vegetation occurs along Paulina Creek. Ponderosa and lodgepole pine approach the edge of this perennial creek, as well as sedges (Carex spp.), grasses and forbs (Charmane Campbell, pers. comm., August 1993). This community is outside the lease areas.

3.11.2.2. Transmission Line Area

Mixed conifer (MC) stands in the transmission line area include a large proportion of ponderosa pine. Canopy closure, age, and density vary. The understory includes snowbrush (Ceanothus velutinus), greenleaf manzanita (Arctostaphylos patula) and pinemat manzanita (Arctostaphylos nevadensis). This vegetation type is unlogged.

Mixed conifer, partial cut (MCPC). A small area 10.1 hectares (25 acres) of this cover type exists in the eastern portion of the corridor. The area has been sold as part of the Fishhook Timber sale. Trees will be spaced 3.7 to 6 meters (12 to 20 feet) apart.

The ponderosa pine, seed tree (PPCC) type has been recently logged with a few seed trees remaining in each cleared area (leave trees spaced 12 meters [40 feet] apart). This type exists in a few patches in the eastern half of the transmission line area.

Open pine (OP) habitat within the transmission line area consists almost exclusively of younger ponderosa pine forests that are even-aged and machine thinned to a plantation type density. Understory vegetation varies from none to areas where snowberry and manzanita are dominant.

3.11.3. Sensitive Plant Species

Several sources were consulted for information regarding sensitive plant species in and surrounding the project study area. These include the U.S. Fish and Wildlife Service (USFWS), the Oregon Natural Heritage Program (ONHP) and the U.S. Forest Service. The USFWS has indicated that no known Federally-designated sensitive plant species are located within the project study area. ONHP has indicated that six species of concern may be present within the project study area. In addition, botanist Charmane Campbell of the Fort Rock Ranger District was consulted for information on sensitive species as well as for a review of the U.S. Forest Service-designated sensitive species list for that area. A total of six sensitive plant species were identified as possibly being present in the study area, based on habitat availability.

These species, their potential for occurring within the project study area, and their Federal and state status are summarized in Table 3.11.4-1.

Surveys for sensitive plant species were performed for the proposed project in June and July 1993 (Lindstedt 1993). Methods for this survey are contained in Appendix C. No sensitive species were observed within the study area.

Table 3.11.4-1 Endangered, Threatened, Candidate, and Proposed Sensitive Plant Species Potentially Occurring in the Project Study Area

Species	Common Name	Federal Status	State Status	Forest Service Status	Observed at Site	Habitat in Study Area*
Castilleja chlorotica	Green-tinged paintbrush	C2	SC	SS	No	Moderate
Aster gormanii	Gorman's aster	C2	SC	SS	No	Moderate
Astragalus peckii	Peck's milkvetch	C2	SC	SS	No	Marginal
Mimulus jepsonii	Jepson's monkey flower	-	-	SS	No	Moderate
Botrychium pumicola	Pumice grape fern	C2	SC	SS	No	Marginal
Allium campanulatum	Sierra onion	-	-	SS	No	Marginal

U.S. Forest Service Codes
SS - Sensitive Species

Federal Status Codes (Category)
T - Threatened
E - Endangered
C1 - Federal Candidate. Information sufficient to support proposing as endangered or threatened.
C2 - Under Review. More information is needed to support proposing as endangered or threatened.
S - Sensitive. A species which is vulnerable or declining and may become a candidate; informal designation.

State Status Codes (Oregon Natural Heritage Database)
T - Threatened
SC - State Candidate. Information sufficient to support the appropriateness of being listed as threatened, rare or sensitive.
M - State Monitor Species

* Indicates potential level for presence of suitable habitat within project area.

3.12. WILDLIFE

3.12.1. Study Area

The study area for wildlife was defined to include that area comprising the project area, where impacts could occur. This study area is identical to that for Section 3.11, Vegetation.

3.12.2. Wildlife Habitats in the Study Area

Vegetation cover types within the study area are described and mapped in the previous section (3.11, Vegetation).

The dominant cover type present within the lease area north of Paulina Creek is seed-tree harvested lodgepole stands (LPCC) and mature lodgepole stands (LP) (Figures 3.11-2 through 3.11-4; see Section 3.11.2). The LP habitat varies in specific components such as shrub and herbaceous layers and canopy closure. Canopy closures range from 5 to 70 percent in the overstory and 5 to 35 percent in the mid-story when there is an understory of seedling/sapling lodgepole trees. Lodgepole/mixed conifer stands (LP-MC) are located only in the upper portion of the roadless area. Mixed conifer (MC) stands in this part of the lease area are generally associated with cinder cones. Overstory trees are predominantly large diameter (46 to 102 cm [18 to 40 inches] dbh) and stands are generally multi-layered.

Lodgepole pine regeneration stands (CC) are located throughout the lease area both north and south of Paulina Creek.

3.12.2.1. Transmission Line Area

The transmission line area contains five general habitat types: lodgepole regeneration (CC), mature lodgepole pine (LP), ponderosa pine-seed tree type (PPCC), open pine (OP), and mixed conifer (MC) (Figure 3.11-4). These types are described in Section 3.11.2. OP-2 is similar to OP-1 except that OP-2 has understory layers. Mixed conifer habitat is predominantly ponderosa and lodgepole pine with scattered white fir (see Figure 3.11-4). The MC-1 stands contain larger diameter trees (up to 76 cm [30 inches] dbh). MC-2 areas have smaller diameter trees than those in MC-1. Mixed conifer stands at the western end of the transmission line area contain a bitterbrush and ceonothus component not common in the other mixed conifer stands.

A summary of wildlife habitat components by specific project sites is located in Section 4.12, Wildlife.

3.12.3. Management Indicator Species

The Deschutes National Forest Management Plan lists 18 individual species or groups of species as Management Indicator Species (MIS). MIS are used as a management tool to ensure a diversity of habitat types, species, and populations throughout the forest. Standards and guidelines (S&Gs) for MIS can be found in Chapter 4 of the Forest Plan. In the Deschutes National Forest, MIS include bald eagle, northern spotted owl, large raptors (including the golden eagle, red-tailed hawk and osprey), accipiter hawks (including northern goshawk, Cooper's, and sharp-shinned hawk), great gray owl, woodpeckers as cavity nesters, waterfowl, peregrine falcon, wolverine, elk, mule deer, American marten, Pacific western (formerly Townsend's) big-eared bat, and great blue heron. Of the 18 listed MIS, 15 are likely to or may occur within the project area. Suitable habitat does not exist for great blue heron, northern spotted owl, or waterfowl.

Many MIS are also listed by the state of Oregon, U.S. Forest Service, and U.S. Fish and Wildlife Service as species of concern. Status designations are provided in parentheses for all species. MIS that are Threatened, Endangered, or Candidate species are discussed in a separate section below. Additional information on Federally listed threatened, endangered, or candidate species can also be found in the Biological Evaluation located in the Analysis File. A summary of these species is presented in Table 3.12-1.

Mule Deer (MIS) Mule Deer are an MIS for winter range in Management Area 7 (MA7), an area located outside the project area, within the Deschutes National Forest (NF). Outside MA7 deer are managed for summer range (Forest Plan [FP], Chapter 4). The project area is considered summer range and is managed for a mosaic of forested conditions incorporating security areas, thermal cover, travel corridors, fawning grounds, and protection from harassment from other activities, such as roads and hunting pressure. The FP states that if hiding cover is provided, thermal cover is assumed to be present. Within the entire project area optimal thermal cover (at ≥ 60 percent canopy cover) is lacking. However, marginal habitat (at ≥ 40 percent canopy) comprises about 62 percent of the entire project area. Potential fawning areas are limited to the riparian zone of Paulina Creek which lies south of the project footprint. Mule deer were observed throughout the project area. A high use area was identified in the extreme northeastern portion of the lease area and its extent is roughly indicated as the hatched area in the northeast corner of Figure 3.12-1. This area is also heavily used by elk (see below).

Table 3.12-1 Summary of TES/MIS Species Occurrence in Project Area

Species	Status	Suitable Habitat Exists on Project Area	Known to Occur on Project Area
Peregrine falcon	FE/SE	No	No
Bald eagle	FT/ST	Yes	Yes, active nest at Paulina Lake
Wolverine	C2/ST	Yes	Possibly uses area for travel and feeding
Pacific western big-eared bat	C2/SSC	No	No
Mule deer/elk	MIS	Yes	Yes, movement generally random. High-use area in northeast corner.
American marten	SSC/MIS	Yes	Yes
Osprey	MIS	Yes	Yes, nest sites located.
Red-tailed hawk	MIS	Yes	Yes
Golden eagle	MIS	No	May use area for travel/migration.
Northern goshawk	SSC/ MIS	Yes	Yes
Cooper's hawk	MIS	Yes, along transmission line area.	Not recorded
Sharp-shinned hawk	MIS	Small pockets located in ponderosa/mixed conifer stands along transmission line area	Yes
Three-toed woodpecker	SSC/MIS	Yes	Yes
Black-backed woodpecker	SSC/MIS	Yes	Yes
Great gray owl	SSV	Yes	No, but likely. Has been observed near project area and suitable habitat exists on project area.
Flammulated owl	SSC	Yes	Yes

FE	Federal Endangered	C2	Federal Candidate
FT	Federal Threatened	SSC	State Sensitive Critical
SE	State Endangered	SSV	State Sensitive Vulnerable
ST	State Threatened		
MIS	Management Indicator Species		

Elk (MIS). Elk are also managed for summer range within the project area. Habitat objectives have been developed jointly by the U.S. Forest Service with the Oregon Department of Fish and Wildlife (ODFW). Key elk habitat areas are identified in the FP, Appendix 16, and are located 19.3 km (12 miles) west/northwest and 24 km (15 miles) north/northwest of the proposed drill sites at the Fall River and Ryan Ranch areas, respectively. Elk that summer in the west Newberry area winter in these areas. In general, an area considered as elk summer range includes hiding and thermal cover and calving grounds near water sources. Water is lacking within the project study area with the exception of Paulina Creek. Elk have been observed in the study area, but usually as individuals. No more than three elk together were ever observed at one time. An area of good summer forage is located in the open sedge meadows on the south-facing slope in the northeast corner of the study area. (See hatched area, Figure 3.12-1.) A heavily used game trail runs north-south through the northeast corner of the study area.

American Marten (MIS/State Sensitive). American marten inhabit a variety of forest communities but seem to prefer extensive stands of relatively dense lodgepole pine, mature or old growth mixed conifer, or mountain hemlock forest containing abundant dead woody material as habitat for denning and foraging. Canopy closure is not less than 50 percent in the most heavily used areas.

Daytime resting sites may be 1.7 meters (6 feet) or more above the ground in live trees. Marten require large blocks of suitable habitat for denning and foraging, usually a minimum of 121-plus hectares (300-plus acres). Outside of designated Management Requirement (MR) areas, marten require additional cover for dispersal. This habitat is necessary to provide for genetic integration with other individuals to maintain a healthy population.

The mixed conifer stands throughout the project area generally lack sufficient numbers of dead/down logs to qualify as suitable marten habitat. During winter tracking surveys, American marten tracks were identified in the mixed conifer forest or in mature lodgepole pine that had at least a 40 percent canopy closure. Marten tracks were also observed less frequently in lodgepole pine regeneration stands or in clearcuts. In these habitats, marten tracks often crossed at the narrowest point between mature stands of trees. Suitable marten habitat does exist at certain well pad sites. Specific information on these sites is contained in Section 4.12.

Large Raptors: Osprey, Red-tailed Hawk, and Golden Eagle (MIS). The osprey, red-tailed hawk, and golden eagle are managed within a specially designated area (MA5), which is not located in the study area. Outside of MA5, protection is afforded to active nest sites through maintenance of a 91-meter (300-foot) vegetated buffer around the nest. Ponderosa pine is a preferred perching tree for these species. Osprey have been observed generally to the west of Paulina Lake and are known to nest near Paulina Creek and the caldera. Osprey have been observed flying over the study area. Suitable nest trees are generally lacking throughout the project area; however, two nest sites that may be osprey nests were located in the eastern portion of the lease area in Section 21. A known active nest is located about 0.4 km (0.25 miles) north of the junction of Roads 9735 and 600. Golden eagles have been sighted several miles north and south of the project site. Suitable habitat for golden eagles is lacking in the project vicinity. It is unlikely that these birds occur on a regular basis within the project area. Red-tailed hawks have not been recorded as occurring within the project area, although it is likely (due to the availability of suitable habitat) that they utilize the area during some part of their life cycle. None of these three species is known to occur within the project area.

Accipiter Hawks (MIS). Accipiters were selected as MIS to monitor impacts to nesting habitat, including the presence of nest trees. Nesting habitat for the three accipiter species is dissimilar. Although nesting habitat may be generally lacking throughout the project area, wide-ranging accipiters, such as the northern goshawk, likely use the area for foraging.

Northern goshawk (MIS/State Sensitive). The northern goshawk most often prefers large and mature mixed conifer, mountain hemlock, and ponderosa pine forests usually near a perennial water source. The Forest Plan defines a goal of 30 pair of goshawk to be established outside of Wilderness and the Oregon Cascades Recreation Area in suitable lodgepole pine forests. Potentially suitable habitat for northern goshawks exists within the lease area. Within the project area, the lodgepole pine stands have been dramatically affected by pine beetle infestation. Mortality of these trees has resulted in a lack of suitable nesting habitat for accipiters within the project area. Goshawks have been sighted in the Paulina Mountains northeast of the project area.

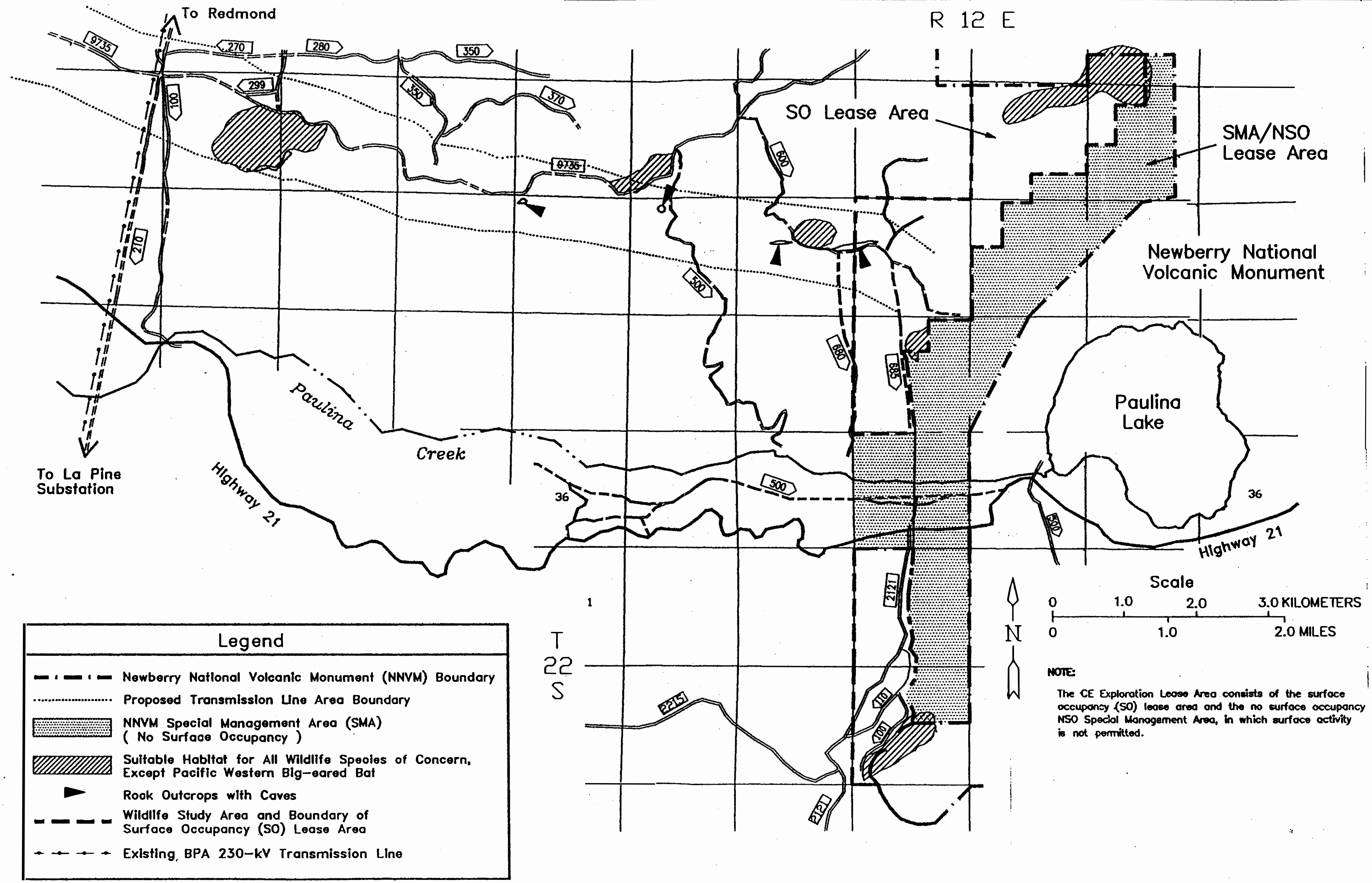
Cooper's hawk (MIS) prefers nesting habitat of 50- to 80-year old dense stands of mixed conifer and ponderosa pine with a closed canopy (USDA 1990). Suitable habitat for the Cooper's hawk exists along the transmission line area in ponderosa pine/lodgepole pine stands. Cooper's hawks have not been identified as occurring within the project area. They have been recorded at Luollo Butte and in the Paulina Mountains north of Paulina Lake.

Sharp-shinned hawk (MIS) prefers dense stands of 40- to 60-year old conifers. These birds will also utilize dense stands of second growth with an over-mature overstory. The Forest Plan requires at least 60 pairs be managed for outside of Wilderness and the Oregon Cascades Recreation Area. Suitable habitat for sharp-shinned hawks generally does not exist within the project area; however, small pockets of suitable habitat can be found along the transmission line area in ponderosa/mixed conifer stands.

NEWBERRY GEOTHERMAL PILOT PROJECT
Deschutes National Forest, Oregon

Suitable Habitats for Species of Concern

Figure 3.12-1



NOTE:
The CE Exploration Lease Area consists of the surface occupancy (SO) lease area and the no surface occupancy NSO Special Management Area, in which surface activity is not permitted.

Woodpeckers (MIS). Woodpeckers are MIS and represent cavity nesting birds, which include passerines and nuthatches. Management of these species is geared towards protection or creation of sufficient snags to allow for present and future nesting and foraging habitat. Habitat capability is managed for 40 percent of potential populations levels within even-aged forests. In uneven-aged forests, 60 percent of potential will be managed for. Within the plant site and drill pad locations, snags and dead/down wood is common (average 4 per hectare [10 per acre]) within the lodgepole pine forested stands. However, the diameter of snags is generally small (4 to 6 inches [10 to 15 cm] dbh). Suitable habitat for woodpeckers exists within some of the well pad sites. Specific information is located in Section 4.12. Within the transmission line area, downed logs are lacking and snags either uncommon or lacking with the mixed conifer and machine-thinned ponderosa stands, respectively.

Black-backed woodpecker (MIS/State Sensitive) has been observed in the open ponderosa pine habitat just south of RD 9735 in the transmission line area. The three-toed woodpecker (MIS/State Sensitive) has been recorded in the northern portion of the project study area along the western fringe of the Paulina Mountains. Favorable foraging habitat for both woodpeckers — lodgepole pine with snags — is present throughout much of the drill pad/plant site area. Suitable habitat for white-headed woodpecker is lacking throughout the project area and verified sightings of this species have not been recorded.

Great Gray Owl (MIS/State Sensitive). The great gray owl is an MIS for nesting and foraging habitat. Nesting habitat characteristics include lodgepole pine overstory with a density of 56 to 72 trees per 0.4 hectare (1 acre) with a 30-cm (12-inch) dbh or greater, and a canopy of 50 to 70 percent closure. For foraging these birds need meadows within 19 to 326 meters (63 to 1,070 feet) of nest sites. Meadow habitat is being created within the project vicinity through salvage logging. A great gray owl was identified 4.8 km (3 miles) south of the southern drill pad sites. It is likely that this species occurs within the project area.

Flammulated Owl (State Sensitive). The flammulated owl prefers mixed conifer habitat that contains white fir and lodgepole components. Trees must be at least pole size, multi-layered, and distributed in clumps. Snags must be present and be at least 30 cm (12 inches) dbh and ranging up to 58 cm (23 inches). U.S. Forest Service reports sightings of flammulated owls along the eastern portion of the proposed transmission line area. Suitable habitat for flammulated owl exists in the mixed conifer stands along the existing and proposed transmission line right-of-way and in the northern drill pad sites.

3.12.4. Threatened, Endangered, and Sensitive Wildlife Species (TES)

The following discussion includes those Federally and state listed taxa that were not discussed above in the MIS section.

Peregrine Falcon (Federal and Oregon Endangered). The peregrine falcon requires the presence of cliffs over 45.7 meters (150 feet) in height for nesting and open meadows or marshes for foraging. Suitable nesting habitat does not exist within the project area. Foraging habitat may exist within open meadow areas outside the project footprint. A juvenile peregrine falcon was observed flying over Paulina Peak in the summer of 1992. No recent observations of these birds have been recorded.

Northern Bald Eagle (Federal Threatened/MIS). The northern bald eagle is a large raptor which preys upon fish, waterfowl, and rodents. It is most often associated with rivers or lakes. Primary habitat components include clean water with abundant populations of fish and old, large perch trees and roost sites located nearby. In winter and during migration, bald eagles may also scavenge in agricultural valleys and wetlands. During these times, eagles congregate in winter roost sites found within old growth stands located close to an available forage base. An active bald eagle nest is located on East Lake. Eagles have been observed flying over the project area. Suitable foraging habitat is lacking within the project area. Potential nesting trees are located within the mixed conifer stands at the eastern end of the proposed transmission line area, although they are less likely to be used owing to their distance from the lakes and ongoing logging disturbance. Paulina Lake has been identified in the bald eagle recovery plan as a potential nest site.

Wolverine (Federal Candidate/State Threatened). Wolverines are most often associated with boreal woodlands, but may be found in almost any habitat type. These wide-ranging carnivores have home ranges as large as thousands of square miles. Availability of denning sites and food supply seem to determine territory size. Wolverines are considered to be increasing in numbers in the Cascade Mountains. No verified sightings of wolverines are recorded with the Deschutes NF by either the U.S. Forest Service or the Oregon Natural Heritage Program. No wolverines or their tracks were observed during field surveys. Wolverines may forage or travel through the project area.

Pacific Western Big-Eared Bat (Federal Candidate (C2)/State Sensitive Critical). Formerly called Townsend's big-eared bat, this mammal is dependent upon caves for roosting and nursery colonies. These caves must have sufficient air movement, day-dark areas for seclusion, and sufficient vegetative cover at entrances to provide security. This species is also intolerant to human disturbance. Open water habitat is used for foraging for insects. Small caves, usually associated with old lava flows, are located in the project area, however, their small size (mostly less than 6 feet [2 meters] deep and 3 feet [1 meter] wide) generally precluded their suitability for big-eared bats. No caves had evidence of prey remains which would indicate bat use. No Pacific western big-eared bat observations are recorded for the project study area. There is an historic sighting of big-eared bats in the Fort Rock Ranger District west of the project area.

3.12.5. Other Wildlife

Herpetofauna. The Pacific tree frog was observed in the study area in 1993. Herpetofauna surveys indicated the presence of the Pacific tree frog, common garter snake, and western toad tadpoles in Paulina Creek and Paulina Lake. The sagebrush lizard was observed along Paulina Creek. No TES herpetofauna were located within the project area or within an expanded study area.

Neotropical Migrants. Neotropical migrant birds are defined as those species that winter regularly south of the Tropic of Cancer. This does not include those western populations, such as ferruginous hawk, which winter in the southern U.S. or northern Mexico. Some species winter in both the tropics and subtropics depending on whether an individual or population is a short- or long-term migrant. Neotropical migrants include the following species, families or groups of birds: turkey vulture, hawks, owls, swallows, flycatchers, warblers, vireos, doves, woodpeckers, mountain bluebird, blackbirds, and finches.

The Deschutes National Forest lists approximately 85 neotropical species existing within the forest boundary (Sharp 1992). Although there are likely additional species present, 16 neotropical migrant species were observed within the study area in 1992 and 1993. These include: turkey vulture, red-tailed hawk, Cooper's hawk, common nighthawk, osprey, dusky flycatcher, olive-sided flycatcher, yellow-rumped warbler, western tanager, chipping sparrow, American robin, mountain bluebird, Swainson's thrush, brown-headed cowbird, solitary vireo, and Calliope hummingbird. Neotropical migrants are generally suffering population declines throughout their range. Within the summer range in North America, current research indicates a decline in those species dependent upon mature and old growth forest habitat.

Bear. A small population of black bear inhabit the area within the Newberry caldera. Six to 12 individuals have been observed in this habitat which provides both food and denning habitat for the bear. Food consists mainly of insects, ants and grubs, and a limited supply of wild berries. The project area may support foraging bears, but no denning habitat has been identified.

3.12.6. Fish and Aquatic Life

The three major water bodies that support fisheries in or adjacent to the pilot project are Paulina Creek and East and Paulina Lakes. Several small ponds within the caldera do not support fish, but they do provide habitat for other aquatic wildlife such as amphibians and aquatic invertebrates.

Paulina Creek is a first order stream originating at the southwest corner of Paulina Lake. Its flow is regulated by a dam at the lake outlet. Only the uppermost two miles of Paulina Creek are within the Monument and Special Management Area. The lower portions are outside the Monument.

A survey of habitat conditions was completed in 1989. The creek has very limited fishery value due to many waterfalls, which block fish movement up and down the creek. Over-winter survival is low because of the lack of pools and low flow. Fish cannot move between the creek and the Deschutes River because there is no surface flow linking the two water bodies. Water rights to the creek flow and about the top three surface feet of Paulina Lake are held by private interests. A few fish can be found in the creek. These may be survivors that escaped over the dam at Paulina Lake, or they may be a small population of resident brook trout. Fishing pressure is very light.

Although some habitat components limit the fishery value, other components are excellent. There is a good supply of food for trout to grow rapidly (stoneflies, mayflies, and other small aquatic insect populations are healthy). In the past, ODFW stocked rainbow trout fingerlings. The trout grew well, reaching a length of 30 centimeters (12 inches) by the following year. They tended to congregate in the larger pools where they were easily caught. If stocking efforts were again undertaken, strict catch regulations would be needed to make the effort successful. ODFW discontinued stocking the creek in the mid-1970s.

East and Paulina Lakes are the two large lakes within the caldera. Surface flow into the lakes comes primarily from snowmelt. The watershed is defined by the rim of Newberry Crater. There are no perennial streams into either lake. Most of the inflow is from underground sources, including hot springs.

ODFW takes primary responsibility for management of the fish populations, and sets fishing regulations. There are no special bait or tackle regulations. ODFW is developing a new management plan for the Upper Deschutes River basin, including the two caldera lakes. Comments from the Deschutes National Forest, other agencies, and the public will be incorporated into the fish management plan, which will be completed by 1995. The Forest Service is working with ODFW to coordinate goals and the desired quality of the fishery for the lakes.

Blue and tui chubs (also called roach) were introduced to both lakes in the 1920s by anglers who used them as live bait. Efforts to control their populations have covered 50 years. As early as 1940, the Oregon Wildlife Commission reduced their numbers in order to increase trout productivity.

The lakes are valuable as a fishery for several reasons, not only from an angling and recreation perspective. The same qualities that support such a productive fishery also support a wide variety of wildlife. Osprey, bald eagles, belted kingfishers, and common mergansers are some of the birds that prey on fish. Mammals in the caldera that eat fish and crawfish include otter, raccoon, mink, and black bear. Additional species depend on some of the same foods that the fish eat. For example, Barrow's goldeneye feed on aquatic invertebrates.

Although neither lake had fish prior to their release in 1912, both lakes are now productive fisheries. Fingerlings stocked by ODFW grow very well, reaching catchable size within six months of their release. The high productivity is related to the concentration of dissolved nutrients that support food for the fish and their prey populations. The dissolved nutrients result from the inflow from springs, including thermal springs, under the lakes' surfaces. Snails, shrimp, insects, plankton, crawfish (in Paulina Lake only), and smaller fish are part of the foods for the fish. The record size brown in Oregon (12 kilograms [27 pounds]) was caught in Paulina Lake in 1993. Fish species in the lakes are shown in Table 3.12-2.

Spawning habitat for game fish is essentially non-existent. A very few brook and brown trout spawn in East Lake, apparently near the underwater springs in shallow water. Natural reproduction is insufficient to sustain the angling pressure. ODFW stocks both lakes annually.

Table 3.12-2 Fish Species and ODFW Fish Stocking Program

Fish Species	Paulina Lake		East Lake	
	Occurs	Annual Stocking Program	Occurs	Annual Stocking Program
Rainbow Trout	yes	85,000 fingerlings	yes	115,000 fingerlings
Brown Trout	yes	10,000 fingerlings and year-old fish	yes	10,000 fingerlings and year-old fish
Kokanee	yes	25,000 fingerlings	yes	New program
Brook Trout	no	—	yes	Discontinued
Atlantic Salmon	no	—	yes	Experimental program
Blue Chub	yes	none	no	—
Tui Chub	no	—	yes	none

Paulina Lake provides a valuable source of kokanee eggs for stocking programs in Oregon, Washington, and Idaho. State fishery personnel collect eggs in the fall from fish that gather at the Paulina Lake outlet. The eggs are then taken to hatcheries where they are hatched. The young fish are raised for later release.

Without control, chub populations reach high levels, reducing the quality of fishing experience and competing with trout and kokanee for food. Unlike trout, which have nearly nonexistent spawning habitat in the lakes, chubs spawn in open water, and their reproductive rate is extremely high. Currently, ODFW uses chemical means to keep the chub numbers in check.

3.13. CULTURAL RESOURCES

Cultural resources include prehistoric and historic archaeological sites, historic architectural and engineering remains, and sites of traditional value or religious importance to Native Americans or other ethnic groups. A cultural resource is considered to be a significant historic property when it has been determined that it is eligible for inclusion on the National Register of Historic Places. Cultural resources are significant in local, state, or national history based on their architecture, archaeology, engineering, or culture. To be considered significant a property must possess integrity of location, design, setting, materials, workmanship, feeling and association. They must contribute to an understanding of history or prehistory through the variety, quantity, clarity, and research potential of the information, and must:

- Be associated with events that have made a significant contribution to the broad patterns of our history

- Be associated with the lives of persons significant in our past
- Embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction
- Have yielded, or be likely to yield, information important in prehistory or history

3.13.1. Study Area

The study area encompasses the SO lease area and the transmission line area (Figure 1.3-3).

3.13.1.1. Survey Process

As part of the initial information gathering process, the cultural resources records of the following agencies were reviewed by personnel from Far Western Anthropological Research Group (Far Western) for known cultural resources sites and surveys within the study area and for a 1.6 km (1-mile) area surrounding the study area perimeter:

- Fort Rock Ranger District, Deschutes National Forest
- Prineville District Office, Bureau of Land Management
- Oregon State Office of Historic Preservation

The results of the records search revealed that several cultural resources surveys have been conducted entirely or partially within the study area. These surveys were performed in support of a variety of activities including timber sales, geothermal development and natural gas pipeline construction. The nature and extent of these surveys with reference to the proposed project is discussed below. Based on guidance from cultural resources personnel with the Fort Rock Ranger District of the Deschutes National Forest, 491.7 hectares (1,215 acres) within the study area were identified for an intensive (Class III) pedestrian cultural resources survey. The results of this inventory, performed by Far Western, are provided in a Cultural Resources Technical Report (Gilreath and Wohlgemuth 1993), on file with the Deschutes National Forest. A summary discussion on prehistory, ethnography, and history for the project area and surrounding region is provided below as background data for evaluations of significance.

3.13.2. Existing Conditions

3.13.3. Prehistoric and Historic Setting

The first human occupation of central Oregon probably occurred at the close of the Ice Age in the Paleo-Indian period, roughly 10,000 years before present (Bedwell 1970; 1973.) This period was characterized by mobile hunter/gatherer populations. No sites recorded in the project area date to this time period.

The period following Paleo-Indian, called the Archaic period, has been divided into three subsections: Early, Middle, and Late. Cultural resource evidence within Newberry Caldera from the Early Archaic (10,000 to 7,000 years before present) includes large-stemmed projectile points and many milling stones, and suggests changes in climatic conditions and a greater focus on plant resources.

The Middle and Late Archaic periods span the period from 7,000 years ago to Euroamerican contact, and are marked at the onset by massive volcanic eruptions of Mount Mazama (the site of Crater Lake today), and an increasingly warmer and drier climate. Viewed as a period of increasingly specialized adaptations to environmental settings, large atlatl side-notched points are associated with the Middle Archaic period. The Late Archaic period, a time of adaptation to cooler climatic conditions, is marked by the introduction of the bow-and-arrow which typically used smaller projectile points. Projectile points associated with the Middle and Late Archaic periods have been found in or near the project area.

To date, archaeological research has identified relatively few sites along rivers to the west of the project area. Most of these sites have been small lithic scatters reflecting relatively short-term use or occupation of an area by a small group. However, archaeological research in the project vicinity has yielded a great number of Middle and Late Archaic sites within the Newberry Caldera east of the project area. These sites are concentrated along or near water sources. Paulina Creek appears to have served as a travel corridor between the Deschutes River and the Caldera (Stuemke 1988). Obsidian collection for tool making was a focus of prehistoric populations in the caldera (Connolly 1991).

In the early 19th century, Native Americans had their first interaction with Euroamericans. Records for this period for the project vicinity are limited (Matz 1991). This is due to limited historic records and difficulty in associating artifacts with historic Native American occupations.

3.13.4. Introduction to Native American Concerns

There are several Federal laws and policy which are applicable to the consideration of Native American values. Of particular importance are:

- American Indian Religious Freedom Act of 1978 (AIRFA): Requires Federal agencies to take into account the effect of their actions on Native American traditional religious practices prior to actions being authorized.

- Native American Graves Protection and Repatriation Act of 1990 (NAGPRA): The intent of this legislation is to ensure that disposition of Native American human remains and associated funerary objects shall be controlled by individuals or groups determined to be most closely associated with the materials.

- Traditional Cultural Properties: National Register (U.S. Department of the Interior) Bulletin 38 discusses properties that can be determined to be eligible for inclusion on the National Register of Historic Places because of their association with beliefs or cultural practices of a living community that are rooted in that community's history and are important in maintaining the continuing cultural identity of the community.

Based on this legal mandate, the U.S. Forest Service instituted a program of consultation with Native Americans who might be able to contribute information on traditional use areas and practices in the project area.

During late 1992 and 1993, the U.S. Forest Service initiated contact with the Klamath Tribe because the project study area encompasses lands ceded to the United States by the Klamath Tribe in the Treaty of 1864. Consultation has thus far been through a series of telephone calls, letters and personal contacts. Consultation is ongoing.

During this same period, the U.S. Forest Service also initiated contact with the Confederated Tribes of the Warm Springs Reservation because the project study area encompasses lands within their ethnographically defined traditional use area. Consultation has thus far been through a series of telephone calls, letters and personal contacts. Consultation with the Tribal Council and the Tribal Archaeologist are ongoing.

3.13.4.1. Ethnography

The study area was used by several different bands or tribes, including the Klamath, Tenino, Northern Paiute, Mollala, Cayuse, Nez Perce, and Umatilla, due to its intermediate location between the Great Basin and the Deschutes River drainage basin (Matz 1991).

The Northern Paiute were the principal users of the project area, evidenced by the fact that they were the only group that wintered over in the Bend area. The Northern Paiute consisted of highly mobile family bands that utilized the plant and animal resources widely distributed throughout their areas of travel. Other groups such as the Plateau-based Tenino used the area on a transitory basis, and made use of salmon and root crops.

3.13.4.2. Contemporary Native American Concerns

During the public scoping process, several issues related to Native American concerns were raised. One issue focused on the opportunity for Native American tribes to facilitate the Section 106 compliance process. Because the project proponent had already retained a subcontractor (Far Western Anthropological Research Group) with the approval of the U.S. Forest Service to carry out the Section 106 required studies, no other entities were considered for this aspect of the project. A second issue raised during scoping focused on the need for Native American consultation with appropriate groups, i.e., the Klamath Tribe and the Confederated Tribes of the Warm Springs Reservation. As stated above in Section 3.13.2, both of these groups have been included as part of the Native American consultation process. The scoping process also identified a concern related to possible disruptions to Native American traditional cultural properties. Both the U.S. Forest Service Native American consultation and Far Western's field surveys revealed no traditional cultural properties of concern within the study area. Finally, it is noted that a portion of the project study area encompasses land which was ceded to the United States by the Klamath Tribes in the Treaty of 1864.

Following identification of issues related to Native Americans raised during the scoping process, a consultation with potentially affected Native Americans was undertaken by the U.S. Forest Service. The only comment from Native Americans received thus far with regard to the proposed project is that the Tribal Council for the Confederated Tribes of the Warm Springs Reservation is interested in exploring geothermal development on the reservation and views the proposed project as a pilot project for them as well.

3.13.4.3. Euroamerican History

The first Euroamericans in close proximity to the project area were members of the Peter Skene Ogden expedition of 1826. The region supported few fur bearing animals and was bypassed by this period's large influx of fur traders (Goddard and Bryant 1979). Waves of emigrants to Oregon in the 1840s and 1850s favored routes along the Oregon Trail, far north of the study area.

The first permanent Euroamerican settlements in the project region were founded with development of the first roads into the Willamette Valley from the Cascades. Homesteaders and cattle ranching activity arrived in the project vicinity between the 1870s and 1900s, and used locations such as the project area for summer range.

Large scale logging operations were made possible with the completion of railroad lines from Bend to The Dalles in 1911. The population of the Bend area grew rapidly in the first decades of this century and expanded throughout the region as lumber mill operations were established and as timber stands were harvested farther from Bend.

3.13.5. Previous Cultural Resource Investigations Completed in Project Vicinity

Prior cultural resources investigations within the study area yielded four prehistoric sites, five prehistoric isolates, and three historic sites (Gilreath and Wohlgemuth 1993).

The prehistoric sites in the study area have been characterized as typically small scatters of obsidian flaking waste materials. These sites probably represent short term occupation episodes by small, mobile groups (Gilreath and Wohlgemuth 1993). Historic sites within the study area include sections of railroad grade and single-episode volunteer trash dumps. The railroad grade network is particularly evident in the western end of the transmission line area where many of the grades are currently used as U.S. Forest Service roads.

An intensive (Class III) cultural resources survey plan carried out by Far Western was developed in concert with the Deschutes National Forest Inventory Plan (Davis 1983). This plan identifies areas with regard to their potential sensitivity to cultural resources. Five moderate to high sensitivity parcels totaling 298 hectares (736 acres) were identified for the inventory. These areas were selected because the distribution of archaeological sites in the area suggests that prominent topographic features and their surrounding area have the potential to contain sites. A supplemental survey parcel was aimed at low probability areas in the eastern part of the transmission corridor and the lease holdings where potential well pad locations and gathering system corridor were identified.

In addition to the parcels described above, areas encompassing the proposed well drill pad locations and an additional area along the gathering system corridor were surveyed. In sum, 492 hectares (1,215 acres) were subjected to a Class III pedestrian survey. Additionally, four previously recorded prehistoric sites within the study area were revisited.

3.13.5.1. Survey Results

Although the specific locations cannot be disclosed, the findings of the Class III survey are described below by study area component:

- IFP-240-FRD: eight small obsidian flakes found in a spur road and adjacent skid road. This site is not considered eligible to the National Register of Historic Places (NRHP) as recordation and plotting of the find has exhausted its research potential.

- 1280-FRD-93P: 75 obsidian flakes found in small clearing on lodgepole flat northwest of the Paulina Mountains. Under the provisions of the Programmatic Memorandum of Agreement (PMOA) between the U.S. Forest Service and the Oregon State Office of Historic Preservation (SHPO), this site is considered eligible to the NRHP.

- IFP-239-FRD: nine obsidian flakes widely scattered on the south margin of a proposed well pad. This site is not considered eligible to the NRHP as recordation and plotting of the find has exhausted its research potential.

- 1281-FRD-93-P: 50 obsidian flakes and three biface fragments on a lodgepole flat between the Paulina Mountains and Kawak Butte. Under the provisions of the PMOA between the U.S. Forest Service and the Oregon SHPO, this site is considered eligible to the NRHP.

- 178-FRD-82-P (Update): This site is situated approximately 244 meters (800 feet) outside of the project study area. The site revisit by Far Western found the area to be severely disturbed from logging activities. Seventeen obsidian flakes were observed at the location. Under the provisions of the PMOA between the U.S. Forest Service and the Oregon SHPO, this site is considered eligible to the NRHP.

- 150-FRD-82-P: This site is an obsidian lithic scatter in a planted clearcut. The site has been bisected by a railroad grade. There appears to be the potential for undisturbed subsurface prehistoric deposits at this location. Under the provisions of the PMOA between the U.S. Forest Service and the Oregon SHPO, this site is considered eligible to the NRHP.

- 174-FRD-82-H: Historic logging railroad grade - no associated artifacts. NRHP eligibility of this site is deferred pending completion of the Railroad Grade Programmatic Memorandum of Agreement (RGPMOA) between the Advisory Council of Historic Preservation (ACHP), the Oregon SHPO and the U.S. Forest Service.

- 289-FRD-85 (Update): Originally recorded as containing 20 obsidian flakes, the site revisit yielded only three observable obsidian flakes. Under the provisions of the PMOA between the U.S. Forest Service and the Oregon SHPO, this site is considered eligible to the NRHP.

- 1216-FRD-92-H: Six railroad segments associated with the Shevlin-Hixon logging railroad complex have been recorded within the Transmission Line Area. The segments vary in length and integrity. One of the segments located at the western end of the corridor contains deteriorating ties. NRHP eligibility of this site is deferred pending completion of the RGPMOA between the ACHP, the Oregon SHPO, and the U.S. Forest Service.

- 775-FRD-89-P (Update): A site revisit relocated 10 of the 30 originally recorded obsidian flakes in this small lithic scatter. Under the provisions of the PMOA between the U.S. Forest Service and the Oregon SHPO, this site is considered eligible to the NRHP.

- 1124-FRD-91: Small single-event trash dump containing household food tins and glass. This site is probably associated with the logging railroads. NRHP eligibility of this site is deferred pending completion of the RGPMOA between the ACHP, the Oregon SHPO, and the U.S. Forest Service.

The Far Western survey did not locate any burials, associated funerary objects, unassociated funerary objects, sacred objects, or objects of cultural patrimony. Discovery of such cultural resources requires agency consultation with affected Native American groups under provisions of the National Historic Preservation Act, the Archaeological Resources Protection Act, and the Native American Graves Protection and Repatriation Act.

3.14. HUMAN HEALTH AND SAFETY

The proposed project would involve the transportation, storage, use, and disposal of products and processes during the exploration, development, and utilization phases that could affect human health and safety. Additionally, it would serve to bring greater human and industrial activity into a forested area which is susceptible to fire.

3.14.1. Study Area

Human health and safety concerns are related to all of the communities surrounding the project area. To ensure consideration of effects on potential human populations, the study area for this analysis has been defined to include the project region (the project area, NNVM, north to the city of Bend, and south to LaPine).

3.14.2. Existing Conditions

The project area is presently nonurbanized and undeveloped. The nearest population centers are Bend, approximately 39 km (24 miles) to the northwest, Sunriver, approximately 16 km (10 miles) to the northwest, and LaPine, approximately 16 km (10 miles) to the southwest. Population in the immediate vicinity to the project area is primarily transient recreational users of the surrounding area. It has been used for recreation and commercial timber production for a number of years (Bonneville Power Administration 1993a).

3.14.2.1. Hazardous Materials

The existing likelihood of substantial chemical spills and discharges in this area appears to be low. Hazardous materials are currently transported along Highway 97, which runs along the western edge of the study area. Data from the Oregon Public Utilities Commission (Oregon PUC 1987), summarized in Tables 3.14-1 and 3.14-2, provides baseline values for current amounts of hazardous materials transported through the study area. The values shown are from the Klamath Falls point of entry and are for north bound traffic only. Assuming there is no net loss or gain between Klamath Falls and the study area, the PUC data indicate the average daily number of placarded trucks heading north on Highway 97 is 12.3. (Placards [signs posted on the side of a vehicle] are used to identify hazardous materials contained in the trucks.) This is 2.1 percent of the total vehicular traffic.

Table 3.14-1 Percentages of Placarded Trucks

Placard	Percent
Flammable	51%
Corrosive	16%
Flammable Gas	16%
Dangerous	11%
Oxidizer	3%
Flammable Solid	3%

Source: Oregon PUC (1987)

The Oregon Department of Environmental Quality (DEQ) is the primary agency responsible for regulation of hazardous wastes in the state. A Hazardous Waste Collection (storage) and/or treatment permit from DEQ may be required for the treatment storage and disposal of these wastes. Under the Oregon Administrative Rules (OAR 340), DEQ implements the state's hazardous waste management regulations and parts of the Federal RCRA. In Oregon, hazardous wastes are defined to include EPA-identified hazardous wastes, as well as additional wastes. These additional wastes are regulated in Oregon because they are toxic, persistent in the environment, or carcinogenic. The storage or use of certain materials (e.g., petroleum products) may trigger the requirement of various plans as detailed in Section 4.14, Human Health and Safety.

Permits would need to be obtained from a number of agencies before power plant construction and operation could begin. Possible hazardous waste-related permits that may need to be obtained from DEQ include the following:

- Resource Conservation and Recovery Act (RCRA) compliance (administered by the DEQ)
- Hazardous Waste Collection (storage) and/or treatment permit

Table 3.14-2 Average Daily Weight/Volume of Hazardous Material

Type of Material	Weight kilograms-kg (pounds-lbs)		Volume liters-lt (gallon-gal) cubic meters-cu mt (cubic feet-cu ft)		
Flammable	377,954 kg (833,232 lbs)	+	52,547 lt (13,883 gal)		
Combustible			19,114 lt (5,050 gal)		
Corrosive	19,132 kg (42,180 lbs)				
Flammable Gas	1,174 kg (2,588 lbs)	+	23 cu m (819 cu ft)		
Non-Flammable Gas	45 kg (100 lbs)	+	45 cu m (1,590 cu ft)		
Oxidizer	6,352 kg (14,004 lbs)				
Flammable Solid	730 kg (1,610 lbs)				
Totals	65,230 kg (143,805 lbs)	+	71,661 lt (18,933 gal)	+	68 cu mt (2,409 cu ft)
Yearly Totals	23,808,931 kg (52,488,825 lbs)	+	26,156,412 lt (6,910,545 gal)	+	24,901 cu mt (879,285 cu ft)
Yearly Number of Trucks	4,490				

Source: Oregon PUC (1987)

3.14.2.2. Fire

Fire has always played a role in the forest, both in and around the study area. Lodgepole pine is the predominant forest type in the project area. This forest type is associate with a moderate-severity fire regime (Walstad et al. 1990). Moderate-severity regimes are infrequent (25-100 years) partial stand replacement fires. Historically in Central Oregon, forest fires of low to moderate intensity occurred every 8 to 12 years. Within the nearby NNVM, the scarcity of continuous fine surface fuels (0.63 cm [0.25 inches] diameter or less), the large areas of lava flows, and the rain commonly accompanying thunderstorms effectively limits the spread and severity of fires.

Records indicate that from 1908 to 1992 there were three large (41+ hectares [100+ acres]) fires within the NNVM and 6 large fires that were in the proximity of the NNVM. From 1970 to 1992, there were 1,257 fires in the Fort Rock district of the Deschutes National Forest. Of these, 1,189 (94.6 percent) were less than or equal to 0.4 hectare (1 acre) in size, and 1,231 (97.9 percent) were less than or equal to 4 hectares (10 acres). The average number of fires per year was 55, with a minimum of 17 and a maximum 119.

Wildfire protection in the Deschutes National Forest consists of fire prevention, detection, and suppression. The Deschutes National Forest fire policy "emphasizes that all wildfires receive timely and energetic suppression action that minimizes suppression costs" (Barton 1993). Suppression strategies range from immediate control to containment and confinement.

Wildfire detection is primarily performed by six lookouts supplemented with aerial detection after lightning storms on high risk or extreme fire days and periods of reduced visibility. Public reporting of wildfires accounts for approximately 33 percent of fire reports.

A fire prevention plan that includes the study area is prepared annually for the Deschutes National Forest. The goal is to minimize preventable human caused fires. In addition to the annual plan, public fire safety education programs and industrial fire inspections are performed.

3.14.2.3. Air Pollution

Estimated mean background concentrations, and associated standards, for several air pollutants are listed in Section 3.5, Climate and Air Quality.

3.14.2.4. Electric and Magnetic Fields (EMF)

All electric transmission lines, such as those in the proposed project, produce electric and magnetic fields. As described in BPA (1993c), "an electric field is basically invisible lines of force that repel or attract electric charges. Electric field strength is described in terms of voltage-per-unit-distance at a specified position." A "magnetic field is measured in terms of lines of force per unit area."

The State of Oregon and BPA have set standards for electric field strength for transmission rights-of-way. There are no Federal standards. Oregon has an electric field standard of 9 kV/per meter on a transmission right-of-way. BPA's standard is 9 kV/m maximum field strength with 5 kV/per meter at the edge of the right-of-way (BPA 1993c).

There are no standards set by the State of Oregon, BPA, or the Federal government for magnetic fields.

Corona occurs in regions of high electric field strength on conductors, insulators, and hardware when sufficient energy is imparted to charged particles to cause ionization (molecular breakdown) of the air. This can result in an audible hissing, popping, or crackling sound. Corona may result in radio and television reception interference by generating a high-frequency noise called electromagnetic interference (EMI). EMI is the static sometimes heard over an automobile radio when driving beneath high-voltage lines. It is usually associated with higher voltage lines, i.e., 345 kV and above.

3.15. ECONOMIC AND SOCIAL CHARACTERISTICS

3.15.1. Study Area

The study area was defined to include all large communities within 160 km (100 miles) (road distance) of the project site in central Oregon. Socioeconomic studies indicate that whereas operations employees tend to locate within easy commuting distance of their work site, construction workers for large power plant projects commute as much as 160 km (100 miles) (one-way) to travel to construction sites. Additionally, temporary migrant workers typically tend to prefer larger communities with more amenities and services over smaller ones. Communities within the designated study area include Bend, Redmond, LaPine, and Sisters in Deschutes County; Prineville in Crook County; and Madras in Jefferson County (Figure 3.15-1). Bend, which is about 64 km (40 miles) from the project site and the largest community in the study area, would likely attract most of the nonlocal construction workers and nearly all of the nonlocal operations workers. Therefore, this community is described in more detail below.

3.15.2. Population

Table 3.15-1 presents current and historic population counts for counties and communities in the study area. Eight counties of Oregon recorded high population growth rates (10 to 28 percent) between 1980 and 1990. Jefferson and Deschutes Counties were among these eight counties. Bend is the largest community in the study area, with an urban area population of about 28,000 (1993). It is the second fastest growing community in Oregon. The projected population growth rate for Bend for the next 5 years is about 2.5 percent per year (Worell 1993).

The population of Deschutes County increased from 32,000 to 62,000 between 1970 and 1980. It declined during the 80s, then increased to 70,000 by 1990. In July, 1993, the population was 88,500, with Deschutes County having the highest growth rate in Oregon. The population is now estimated to be over 90,000. The current growth rate is about 4 percent a year. If this trend continues, the population will double in 17 years. The growth rate over the next 15 years is expected to be between 2 and 4 percent a year (Read 1994).

3.15.3. Economy and Employment

The distribution of wage and salary employment for the three-county study area is presented in Table 3.15-2. Trade and services provide almost 50 percent of the wage and salary employment, and constitute the two largest sectors of the economy. Manufacturing accounts for about 18 percent of wage and salary employment, with almost 70 percent of this employment in the lumber and wood products industry. About 17 percent of jobs are in government. Construction accounts for about 5.4 percent of total employment. The number of manufacturing and construction jobs has declined by 2.5 and 2.0 percent, respectively, between 1991 and 1992 (Central Oregon Economic Development Council 1993).

Tourism is an important source of income in the study area with its wide variety of recreation resources, including the NNVM. In 1992, approximately $116,000 in fees were collected between May and October at the NNVM.

3.15.4. Housing and Lodging

The total number of housing units in the study area communities are reported in Table 3.15-1. Bend has an estimated 9,004 housing units and is anticipated to increase in urban area. The average cost of a single-family home in Bend is $105,000 (Central Oregon Economic Development Council 1993).

Temporary housing is available in the study area in the form of hotels, motels, bed and breakfast facilities, resorts, RV parks, campgrounds, and rental cabins (Table 3.15-1). Deschutes County has about 4,200 units, of which almost half are located in the Bend urban area.

Redmond and Madras have about 250 units each (Oregon Lodging Association 1993). Additional lodging facilities are available in the communities of Sisters and Prineville, and in the unincorporated portion of the three affected counties, near Sunriver, LaPine, Camp Sherman, Crescent Lake, and Cascade Summit. The annual occupancy rate in the Bend urban area reaches a maximum of 55 percent (55 percent in summer and 45 percent during winters) (Bend Chamber of Commerce, 1993).

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Population Centers and Other Project Features in the Project Vicinity Source: Modified from an Oregon Road Map (Gousha Travel)	Figure 3.15-1

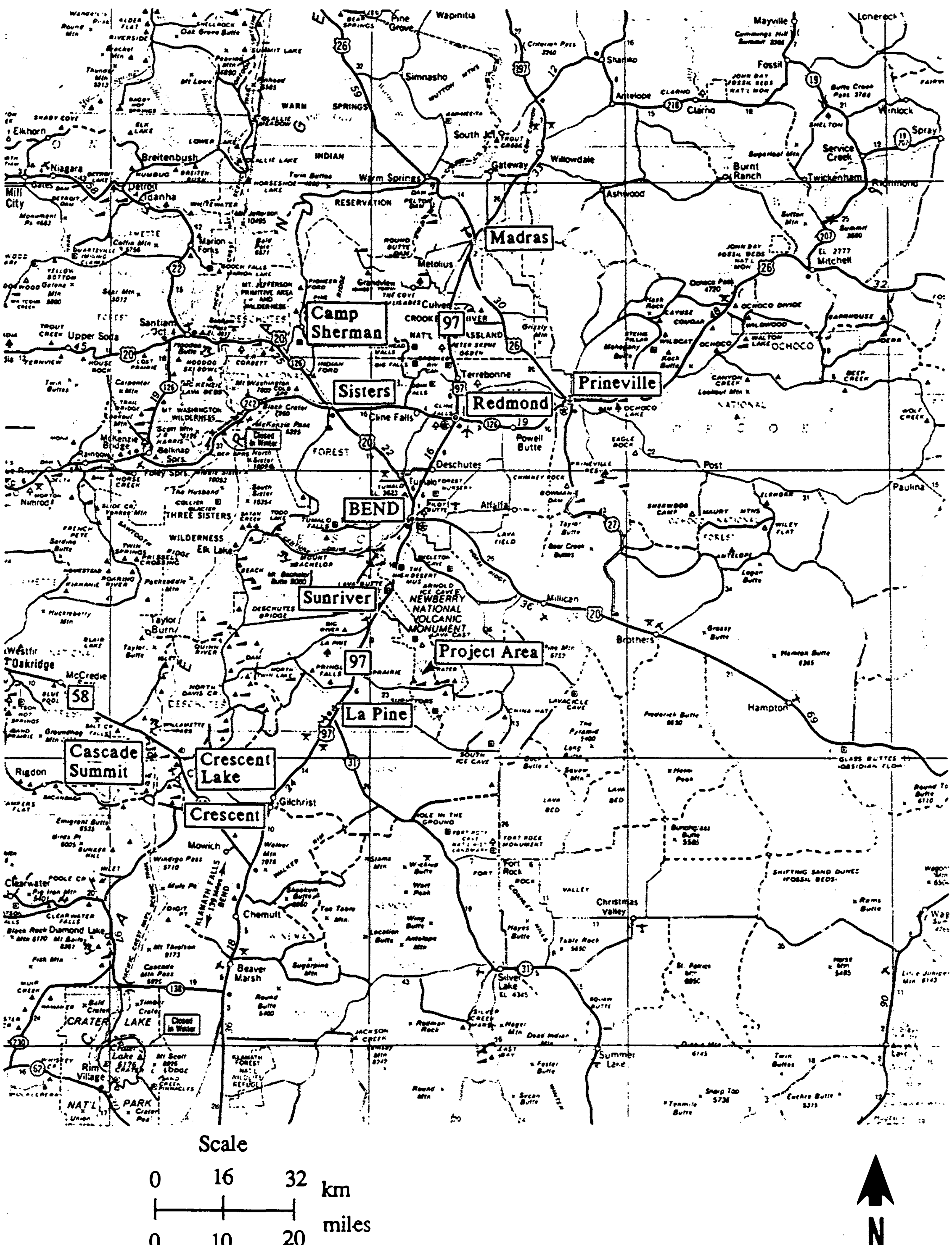


TABLE 3.15-1
Demographic Characteristics and Housing

County/Community	Population						Housing Units	Average Cost of Single Family Unit	Lodging[c,d] (Units)
	1980	1990	Percentage Change 1980-1990	1992	Percentage Change 1990-1992	Percentage Growth 1990-2000			
County									
Deschutes	62,142	75,600	22%	82,600	9	32	N/A	N/A	4,197
Crook	13,091	14,100	8%	15,000	6.8	N/A	N/A	N/A	N/A
Jefferson	11,599	13,700	18%	14,600	6.6	N/A	N/A	N/A	N/A
Communities									
Bend	17,263	20,750	20%	24,715	20	N/A	9,004	$105,000	2,100
Redmond	6,452	7,163	11%	7,163	0	N/A	2,932	89,500	250
LaPine	N/A	N/A	N/A	N/A[a]	N/A	N/A	N/A	N/A	44
Sisters	696	708	2%	760	7	N/A	354[b]	120,000[b]	122
Prineville	5,276	5,435	3%	6,000	12	N/A	2,287	82,000	156
Madras	2,235	3,570	60%	3,820	7	N/A	1,374	52,500	269

Source: U.S. Census 1980 and 1990.

[a] An unofficial estimate of population for LaPine provided by the LaPine Chamber of Commerce indicates that the community has 10,000 residents.
[b] Sisters Planning Department 1993.
[c] Additional lodgings are available in full service resorts (1,161 units), RV Parks and campgrounds (750 spaces) and cabins (137) in Central Oregon.
[d] Oregon Lodging Association 1993.
N/A — Data not available.

Table 3.15-2 Labor Force and Employment in Central Oregon

County/Central Oregon	Labor Force (Dec. 1992)	Unemployment 1992
Deschutes	45,920	3,650 (7.9%)
Crook	7,520	530 (7.0%)
Jefferson	6,890	640 (9.3%)
Total	60,330	4,820
Distribution of Employment (number of wage and salary jobs)		
Manufacturing	8,320	
Lumber and Wood	5,820	
Other Manufacturing	2,500	
Non-Manufacturing	37,040	
Construction	2,440	
Transportation, Comm. & Utilities	1,580	
Trade	12,310	
Finance, Ins. and Real Estate	2,810	
Services and Misc.	10,180	
Government	7,720	

Source: Central Oregon Economic Development Council, 1993.

3.15.5. Schools

The study area communities are served by five school districts (Table 3.15-3). The Bend/LaPine School District maintains a classroom size of 30 to 35 students. Three new elementary schools have been constructed in 1993. One new school is planned for construction in 1994. Most of the elementary and junior high schools are near capacity, and even with the addition of the new schools, all elementary and junior high schools will be at or over capacity (Rexford 1993). The Redmond School District covers an area of 1,440 square km (556 square miles) and has eight schools, of which six are elementary, one junior high, and one high school.

Table 3.15-3 Educational Facilities in the Study Area

School District[1]	Number of Schools	Enrollment (1992)
Bend/LaPine	16	10,205
Redmond	8	4,295
Sisters	3	779
Jefferson County	6	2,700
Crook County	6	2,968

[1]In addition to the listed public schools, there are seven private elementary and secondary schools in the study area, and a community college in Bend.
Source: Central Oregon Economic Development Council 1993.

3.15.6. Utilities and Services

3.15.6.1. Water, Sewer, and Solid Waste

Water, sewer, and solid waste collection and disposal services are provided by each of the municipalities. Some suburban areas are provided water by private water companies. Most of the water supply for Bend is obtained from Bridge Creek (about 75.7 million liters per day [mld]/20 million gallons per day [mgd]). About 15 percent of the city's needs are supplied by wells, especially during summers when water levels in Bridge Creek are low. Outlying areas around Bend are supplied by Avion Water District and Roats Water District (Prowell 1993). Approximately 60 to 70 percent of the homes in Bend are hooked to the city's wastewater collection and treatment system, while the remaining are served by individual septic tanks. The city's wastewater treatment plant currently operates at 50 percent of capacity (Byers 1993).

3.15.6.2. Law Enforcement, Fire Protection, and Health Care

Law enforcement services are provided by city police departments and the county sheriff's office in each of the three counties. The Bend Police Department comprises 37 sworn officers, and has a service ratio of 1.5 officers for every 1,000 residents. The Deschutes County Sheriff's office comprises 50 deputies, and has a service ratio of 1.0 officer for every 1,000 residents (Maniscalo 1993).

The City of Bend Fire Department includes four stations with 55 staff to serve urban and adjacent rural areas (Niendorf 1993). The fire department that is closest to the project site is the LaPine Fire Department covering an area of 262 square km (101 square miles). This department has a full-time staff of 10 fire fighters with 45 volunteers (Hofman 1993). Both Bend and LaPine Fire departments have mutual aid agreements with the U.S. Forest Service and the Oregon Department of Forestry. Other communities in the study area are served by their own fire departments.

Central Oregon is served by four hospitals with a total of 299 beds. In addition health care is provided by 17 immediate care clinics, and Air Life of Oregon (Central Oregon Economic Development Council 1993).

3.15.6.3. Electric Utilities

Three utilities — Midstate Electric Cooperative, Central Electric Cooperative, and Pacific Power and Light — serve Deschutes County. In general, Pacific serves the larger cities (such as Bend and Redmond) and the cooperatives serve the rural areas. Midstate and Central currently purchase all of their energy from BPA. The combined energy sales of the two cooperatives totaled 580,240 megawatt-hours (MWh) in 1992, and are expected to reach 696,000 MWh by the year 2000. Pacific Power and Light does not own major power plant facilities in the area.

Strictly speaking, once the electricity is on BPA's system, it will be mixed into the pool of resources available to BPA. In actuality, since central Oregon imports virtually all of its electricity, output of the Newberry Project will help to serve loads in the Bend-LaPine area.

3.15.7. Public Finance

There is no sales tax in Oregon. Sources of public finance include property tax, forest receipts, mineral leases, transit room taxes, and personal and corporate income taxes. The property tax rate varies with county and community. The 1992-93 rates range from \$17.35 per \$1,000 of assessed valuation for property in Bend to \$24.33 per \$1,000 of assessed value for the City of Madras (Worell 1993). Total property tax revenues collected in the fiscal year 1992-1993 in Deschutes County were \$80,797,948 (Rastovich 1993). Personal income tax rate is about 9 percent and the corporate rate is about 6.6 percent. Deschutes County government collected \$3.64 million in forest receipts, \$1.8 million in transit room taxes, approximately \$24,000 in mineral lease revenues, and \$300,000 from cigarette tax and liquor revenues (Rastovich 1993). Another potential source of public finance is a 10 percent geothermal operating royalty paid to the Federal government. Half of these royalties are returned to the state. Oregon passes the state share through to the county of origin, as per Oregon Revised Statutes 294.055. Royalties are based on the gross proceeds to the developer from the sale of steam or electricity and are paid when a geothermal facility is operating. Presently, there are no geothermal royalties collected in central Oregon.

4.0
EFFECTS OF IMPLEMENTING EACH ALTERNATIVE

4.0 EFFECTS OF IMPLEMENTING EACH ALTERNATIVE

4.1. INTRODUCTION

This chapter describes the anticipated environmental effects of the three alternatives considered in this EIS. Alternative A is the proposal received from CEE, Alternative B was developed in response to key issues raised during scoping, and Alternative C is the no-action alternative. Sections 4.2 through 4.15 address specific resource categories. The subsequent sections that address each resource category are organized in the following subsections:

- Impact Overview: An overview of the impacts that may potentially occur and need to be considered for an analysis of geothermal resource development
- Methods of Analysis: A description of the methods used for the analysis
- Effects Common to Alternatives A and B: A description of impacts common to Alternatives A and B. The monitoring and mitigation-type measures proposed by CEE to reduce environmental effects are considered in the analysis
- Effects of Alternative A: A description of effects unique to Alternative A, with the proposed mitigation measures and monitoring included in the analysis
- Effects of Alternative B: A description of effects unique to Alternative B. In addition to mitigation measures proposed by CEE, this alternative includes additional measures to reduce environmental effects; these measurements are included in the analysis of this alternative
- Additional Mitigation: Additional mitigation and monitoring that could be applied to both action alternatives which is not currently prescribed as part of either alternative
- Effects of Alternative C: A description of the effects of Alternative C, the no-action alternative

The impact descriptions are further subdivided into classes or types of effects, as appropriate in each subsection. The phase(s) of the proposed project (exploration, development, utilization, decommissioning) in which an impact is expected to occur are identified. Mitigation as mentioned above may also include a monitoring element. The effects of measures designed to reduce environmental effects (and monitoring) actions included as part of Alternatives A and B are described to the extent necessary, and are considered in the analysis of impacts. Complete lists of mitigation actions for Alternative A are given in Section 2.4.1, and for Alternative B in Section 2.4.2. Other mitigation measures that could reduce impacts, but are not currently incorporated into either Alternative A or B, are described in the additional mitigation subsection. These additional mitigation measures will be evaluated and may be incorporated into the selected alternative in the Record of Decision.

Each impact section responds to concerns and issues expressed about the proposed geothermal pilot project by the public, agency personnel, and technical specialists during the scoping process. Those scoping issues are summarized in Section 1.6.

Sections 4.16 through 4.24 address irreversible and irretrievable commitments of resources, unavoidable adverse impacts, and the relationship between local short-term use of the environment and maintenance and enhancement of long-term productivity. A summary highlighting the differences in impacts of Alternatives A and B is presented in Section 2.5, Comparison of Action Alternatives.

4.1.1. Environmental Baseline Monitoring

Certain measures to protect the environment are required by the regulations governing the development of geothermal resources on Federal land. One of the most important is the requirement for the developer to document the condition of the environment prior to production of the geothermal resource in the utilization phase (establish an environmental "baseline"). The developer is required to maintain a monitoring program after utilization begins in order to detect significant changes in the environment. Recognizing the importance of baseline monitoring, and anticipating development proposals at Newberry, the U.S. Forest Service, BLM, and BPA began a baseline data collection program in 1990.

The regulations governing the development of geothermal resources on Federal land are given in Section 3200 of the Code of Federal Regulations (43 CFR Ch. II). Greater detail on how the regulations are to be implemented is found in the Geothermal Resource Operational (GRO) Orders. The seven GRO Orders cover all phases of geothermal operations from exploration to abandonment.

43 CFR 3262.4 requires the leaseholder to collect "data concerning the existing air and water quality, noise, seismic and subsidence activities, and ecological systems of the leased lands for a period of at least one year prior to production with some of the collection to be continued during production and abandonment." Guidance on how to collect these data is given in GRO Order No. 4 and in the "Guidelines for Acquiring Environmental Baseline Data on Federal Geothermal Leases" in GRO Order No. 5. These guidelines are not a set of rigid or absolute standards. The BLM decides on a case-by-case basis what level of baseline data collection and environmental monitoring is appropriate.

The reason for collecting these data is given in the Guidelines: "The purpose of collecting environmental data is to provide a baseline representing selected physical, chemical, and biological conditions prior to significant disturbance by lease operations against which later environmental data can be compared. This comparison will provide a basis for determining the net environmental change attributable to the operations on the leasehold at any subsequent time."

The types of data collected usually include:

- Air quality
- Surface and ground water quality (hydrology)
- Terrestrial and aquatic plants and animals (biology)
- Noise
- Seismicity (frequency of earthquakes)
- Subsidence

Baselines for air quality, biology, and noise were established in the course of preparing this EIS. The baseline for air quality was estimated based on data collected by various sources and is described in detail in Appendix F-1. Baseline data for seismicity and subsidence would be collected at least one year prior to production. Monitoring requirements are being considered by BLM and the U.S. Forest Service, and would reflect the results of the analysis presented in this EIS. Required monitoring will be summarized in the Records of Decision, and will be detailed in a Monitoring Plan that will be published separately.

At the request of the U.S. Forest Service and BPA, the U.S. Geological Survey (USGS) designed a hydrologic baseline data collection and monitoring program for the Newberry Volcano area. The program involves sampling and collecting data on a wide range of physical and chemical parameters at 21 sites. These sites include surface and groundwater sources, and hot springs. The USGS began collecting data in 1991.

If a project is approved and CEE confirms a developable resource during the exploration phase, and is prepared to proceed through the development phase, they would prepare and submit to the BLM and U.S. Forest Service a plan for baseline data collection in accordance with GRO Order No. 5. Current monitoring activity includes a USGS hydrologic monitoring program that is described under Geothermal Resources in Section 4.4.3. Ongoing meteorological monitoring is being conducted by CEE near proposed Plant Site 1 (see Section 3.5, Climate and Air Quality). Monitoring proposed as part of each alternative is included in the discussions of impacts in this chapter of the EIS. "Additional Mitigation" sections also include monitoring suggestions, where appropriate.

4.2. GEOLOGY AND SOILS

4.2.1. Impact Overview

Geothermal projects are usually located in geologic settings where there has been faulting and/or volcanic activity. It is these geologic processes that have created the vertical conduits for the movement of magma sufficiently close to the earth's surface to create the unusual heat source essential for a geothermal resource. A number of potential geologic hazards are associated with these settings.

Soils at geothermal projects are often derived from relatively recent volcanic rock material and are not well developed. Protection of the soil from excessive disturbance and erosion is important. Most potential geologic- and soils-related impacts from the project would be likely to occur during the preconstruction geotechnical investigation of the site; during drilling of the geothermal production wells; and during construction of the plant and transmission lines.

4.2.2. Method of Analysis

Geology and soil characteristics for the project area were determined by a review of a number of sources which are listed in Section 6.0, References.

4.2.3. Effects Common to Alternatives A and B

The environmental protection (mitigation) measures that were proposed by CEE or included in Alternative B would be required and are described in Chapter 2 and in the following paragraphs. These measures would apply to either Alternative A or Alternative B.

4.2.3.1. Roads

Road materials such as cinders and rock are the only known mineral resource (other than the geothermal resource) in the project vicinity. CEE proposes, with U.S. Forest Service concurrence, to use road materials from existing pits or quarries for necessary improvements or repair of existing roads and construction sites. Use of these materials would likely be needed during all four phases of the project.

4.2.3.2. Volcanic and Geothermal Activity

It is unlikely that drilling, development, and production of the steam wells will induce either volcanic or hydrothermal explosions. Drilling and production would occur during the exploration, development, and utilization phases. The movement of magma is controlled by geologic forces, such as mountain building and plate tectonics, and rock pressures, such as the difference in the density of magma and solid rock. These forces are orders of magnitude greater than the slight changes in fluid pressure which may result from geothermal development. The drilling and testing of the steam wells would cause little change in the formation pressure in the hydrothermal reservoir. Since the fluid pressure in the reservoir is maintained during production of the steam wells by injection of fluids, it is not expected that the production activities would induce volcanic activity. Geothermal explosions result when the steam pressure within the geothermal reservoir becomes greater than the weight of the overlying rock. This condition is most likely to occur in shallow reservoirs where the rock pressure is low. In Newberry Caldera the geothermal reservoir lies several thousand feet below the surface and the rock pressure is more than adequate to suppress steam explosions. Effects on the geothermal resource are addressed in more detail in Section 4.4, Geothermal Resources.

4.2.3.3. Geologic Hazards

The proposed project facilities would be sited on stable ground and designed for potential hazards. CEE would implement certain measures to minimize risk to the facilities (and possibly the environment). Sites posing potential geologic hazards (i.e., landslides) would be identified and avoided during facility siting. Geotechnical studies would be performed prior to plant construction to ensure site stability; recommendations of the studies would be incorporated into plant and facility design. Facilities would be designed to accommodate the maximum predicted seismic event. Site specific geothermal studies would be performed either prior to or during the exploration phase.

4.2.3.4. Soils and Erosion

CEE proposes to minimize the impacts on soils by implementing measures to limit the size and number of disturbances. Surface disturbances would be minimized by limiting operations to designated areas approved by the U.S. Forest Service. All site grading would be a balanced cut and fill, with no soil import or export required. Facilities would be located near or within existing clear cut areas when practical. Drill sites would be confined to minimize ground disturbance. All well testing facilities would be constructed on previously cleared areas (well pads). Vehicles would keep to designated roads when possible to minimize soil compaction on undeveloped areas. Efforts to minimize ground disturbances would be implemented during all four phases of the project by the development of operations procedures that include and are communicated to all personnel (company, service company, etc.) that would visit the project site.

Occasional traffic along a transmission route for maintenance purposes is not expected to create soil compaction problems. Snow plowing is expected to be limited to existing roads and construction sites, thereby minimizing off-road compaction.

Measures to prevent or reduce the amount of soil erosion have been proposed. Cut-and-fill slopes would be engineered and terraced according to height, and compacted and maintained to minimize erosion and provide slope stability. Project construction would include culverts, berms, and ditches to direct runoff and minimize erosion potential. The surfacing and maintenance of roads with dust abatement materials would also be required for all phases of the project to reduce erosion and dust. These measures will be necessary through all phases of the project, but will be primarily implemented during exploration and development. The U.S. Forest Service requires that all traffic be restricted to designated roads and areas during all phases of the project to reduce the amount of site disturbance, erosion, and soil compaction in undeveloped areas.

Landscaping, including recontouring and revegetation, would be required for exposed areas to stabilize soils and improve aesthetics upon completion of the soil disturbing activity. CEE proposes that upon site abandonment, grades would be contoured and revegetated to their original condition where practicable. Also, if required, additional lay-down areas would not be graded and vegetation would be crushed or cropped and rehabilitated upon completion of the development, utilization, and decommissioning phases.

4.2.3.5. Subsidence

Land subsidence has occurred in some areas, geothermal and otherwise, where large amounts of groundwater have been withdrawn. Generally these areas are sedimentary basins filled with unconsolidated (loose) sands, silts, clays, and gravels. Also, water production is from very shallow wells. At Newberry Volcano, the land surface is underlain by thick layers of dense volcanic lava flows having much higher strength that the sediments in basins where subsidence has been observed. Also, geothermal production is proposed for deep wells that are sealed off from shallow aquifers. These conditions would minimize the chances of ground subsidence occurring due to geothermal production. Natural causes related to volcanic activity may cause ground deformation at Newberry Volcano that would be difficult to distinguish from geothermal-induced subsidence. No mitigation is proposed because the potential for subsidence that affected facilities is considered remote.

Subsidence would not be expected to increase as a result of the project operation, because (1) there is competent bedrock beneath the facility sites, and (2) fluid pressure in the reservoir would be maintained through the injection of spent fluids and waste water.

Prior to production, surveyors would establish benchmarks in the project area as part of the environmental baseline requirements discussed in Section 4.11. If subsequent monitoring of these benchmarks shows subsidence with potential for adverse effects has occurred, mitigation measures could be imposed.

4.2.3.6. Seismic Activity

Some geothermal areas have experienced increased seismic activity associated with geothermal production. Generally these areas had some level of known or suspected seismic activity prior to geothermal development. Production of geothermal fluids may have increased seismic activity in some cases. The earthquakes recorded are typically too small to be felt by the local population (Richter magnitudes less than about 3).

At Newberry Volcano there is no reported seismic activity. This implies that there is not a significant stress field causing earthquakes to occur. Production of geothermal fluids and injection of residual fluids is not expected to change this condition, and no significant increase in seismic activity is anticipated. If seismic activity increased, it would be expected to be on a micro-seismic level and not felt by people in the area. No mitigation is proposed.

Induced seismic activity caused by the operation of the steam wells during the utilization phase would be minimized by the design of the system. Geothermal fluid/steam would be maintained by the injection or reinjection of excess geothermal fluids, excess cooling tower fluids, and plant drains back into the geothermal reservoir through injection wells. Fluid pressures in the reservoir would not be expected to change substantially. (Also see Section 4.4, Geothermal Resources, for a discussion of the potential effects of geothermal production.)

4.2.4. Effects Unique to Alternative A

The construction of the transmission line during the development phase would (for much of its route) follow Road 9735. Although this portion of the route is longer than a "cross country" route it would be constructed and maintained from the existing road which would minimize disturbance to the soils. However, since there a number of curves in the road, guy wires (needing additional cleared areas) would be needed to brace the power poles at curve points. This alternative may preclude or interfere with future expansion work that may be done to Road 9735.

4.2.5. Effects Unique to Alternative B

The amount of road construction in Alternative B during the exploration phase could vary from that of Alternative A, depending on the selection of the well site pads utilized; however, the flexibility created to properly develop the geothermal resource may outweigh the minor amount of increased soil disturbance that may result.

The construction of the "cross country" transmission line during the development phase would minimize the length of the route but would require the building of a construction/service road for much of the length. Disturbance to soils would be greater constructing the transmission line proposed in Alternative B than that proposed in Alternative A.

4.2.6. Additional Mitigation Measures

No additional mitigation measures are suggested.

4.2.7. Effects of Alternative C (No Action)

The no-action alternative would avoid all the potential adverse impacts discussed in this section for the proposed action and the alternative. There would be no opportunity to learn more about the underground geology of the Newberry area, which would have occurred with exploratory drilling.

4.3. WATER RESOURCES

4.3.1. Impact Overview

Geothermal resource use has the potential to affect water sources and water quality in a number of ways. Typically, however, environmental protection features built into the projects greatly reduce impacts. Potential sources of impacts are the disposal of drilling fluids, excess geothermal fluids, process and cooling wastewaters, and stormwater runoff.

4.3.2. Method of Analysis

Data on existing water resources and their quality were compiled from the sources described in Section 3.3. The capacity of the proposed geothermal facility to generate wastewater streams that could affect water quality was examined. Similarly, the effect of the proposed project on surface and groundwater hydrology was examined. Because wastewaters generated by the project are proposed to be either evaporated or injected into the geothermal reservoir, no dispersion modeling was undertaken. An exception was for the prediction of the effects of deposition of air pollutants on water quality. The Climate and Air Quality analysis (Section 4.5 and Appendices F, J, and L) describe expected project emissions and their dispersion.

4.3.3. Effects Common to Alternatives A and B

4.3.3.1. Drilling Waste

Wastewaters produced during exploratory well drilling, including drilling fluids, cuttings and mud, are proposed to be routed to a sump at each well pad. Each sump would consist of a clay-lined open pond. The capacity of each sump would depend on the number of wells to be located at the well pad and would vary between 2,838,750 and 3,785,000 liters (750,000 to 1,000,000 gallons). Fluids produced during well testing, maintenance, and start-up would also be routed to the sump. The sumps would be sized to accommodate the expected volume of wastewater generated during exploration, testing, and start-up. Wastewaters would be temporarily stored in the sumps and then injected into the geothermal reservoir via the injection wells. As noted in Section 2.4.1.2, if accumulated wastewater in a sump should begin to approach its capacity, then fluids would be routed to another sump or drilling would be discontinued until the water level in the sump could be lowered by injection. Should transportation of the mud slurry or wastewater off-site be necessary, the appropriate permits would be sought from ODEQ.

4.3.3.2. Surface Runoff

During exploration, development, and utilization, stormwater from the bermed equipment areas at the well pads would be routed to the lined sumps. Stormwater accumulating in the sumps would be injected into the geothermal reservoir together with drilling and production wastewaters via injection wells.

During all phases of work that involve construction or demolition, surface soils would be disrupted. Major surface-disturbing construction would occur during exploration, development, and decommissioning. Less extensive construction may occur during utilization, as facilities are modified. During heavy rain, soil erosion would be accelerated in the disturbed areas. However, increased erosion is likely to be limited to localized areas because of the permeable nature of soils at the site. Runoff is unlikely to develop sufficient volume or velocity to carry construction-related silt into a surface water body. Drainage patterns in the project area would carry runoff away from the nearest surface water body, Paulina Creek. The on-site storage and disposal of mud slurry and wastewater will comply with ODEQ rules for degradation of natural surface and groundwater quality. A Water Pollution Control Facilities or National Pollutant Discharge Elimination System (NPDES) permit will be obtained, if necessary.

Where feasible, above-ground pipelines would be laid along existing roads and along other previously disturbed routes to minimize surface disturbance. In addition, construction sites would be graded to avoid concentrating runoff and possibly causing soil erosion.

Runoff, infiltrating stormwater, or snow-melt water could become contaminated with construction materials, if these materials were not stored and handled carefully. If fuel and/or solvents for construction vehicles or heavy equipment were spilled, contaminants could percolate into the ground; however, given site conditions, the quantities involved would not be sufficient to substantially impair groundwater quality.

Soils at the well pad and power plant sites are very permeable. At present, much of the precipitation that falls on the site is intercepted by vegetation and evapotranspires or percolates into the soil. Runoff occurs only during heavy rainfall or periods of unusually rapid snow melt. Development of the proposed project would alter the rates of stormwater runoff and infiltration at the power plant and well pad sites. Vegetation would be cleared from the 10.6 hectare (18.5-acre) power plant site and from up to 14 production and injection well pad sites. At each production well pad site an area of 2 hectares (5 acres) would be cleared. Each finished production well pad would have an area of about 1.4 hectares (3.4 acres). Temporary drainage during construction would be designed to take advantage of the permeable soils.

At the power plant site, an area of about 7.5 hectares (13 acres) would be graded and fenced. Most of the graded area site would be covered by impervious surfaces such as building roofs and concrete and asphalt paving. Paved areas would be enclosed by curbs or berms. Stormwater runoff from the paved equipment areas would be collected in storm drains and piped to an oil/water separator. After oil is removed, the stormwater would be routed to the water storage pond. Roof drains would direct rain water and snow melt to the local topography . The storm drainage system would be designed to contain runoff from the 100-year return frequency storm. The on-site storage and disposal of mud slurry and wastewater will comply with ODEQ rules for degradation of natural surface and groundwater quality. A Water Pollution Control Facilities or National Pollutant Discharge Elimination System (NPDES) permit will be obtained, if necessary. Drainage of the cleared area outside the fence would be unchanged from the existing condition. No site runoff would drain to Paulina Creek or Paulina Lake.

Under normal power plant operating conditions, stormwater runoff and infiltration into the ground would be reduced from the predevelopment condition. There would be no increase in runoff-related soil erosion. The reduction in infiltration, a maximum of 49,300 cubic meters (40 acre-feet) per year would be negligible, relative to the estimated 276 million cubic meters (224,000 acre-feet) of groundwater recharge that occurs annually on the northern and western slopes of Newberry Volcano.

All potentially contaminated stormwater would be contained and injected into the geothermal reservoir under Alternatives A and B. Accordingly there would be no adverse effect on surface or groundwaters. However, because the proposed project site meets the regulatory definition of an industrial facility with an area of more than 2 hectares (5 acres) it may be necessary to obtain a stormwater discharge permit under the Clean Water Act. The NPDES program is administered by the Oregon Department of Environmental Quality.

4.3.3.3. Sanitary Waste

During exploration, development, utilization, and decommissioning, portable toilets would be installed wherever construction crews are working. Sanitary wastes would be pumped from the portable toilets and trucked offsite to an approved disposal point. There would be no adverse effects on water quality.

Staff operating the geothermal power facility would produce sanitary waste. Sanitary waste would be disposed to an engineered septic system. The septic system would consist of a septic tank and leach field. The system would be sized to handle wastes from 12 people per 8-hour shift and would be installed within the boundary fence. The system would have sufficient capacity to accommodate short-term increases in wastewater flow, which would, for example, occur during bus tours of the facility, without any loss of effectiveness. After treatment in the septic tank, liquid fractions of the waste would percolate into the ground through the leach field. The septic tank would be pumped out periodically and the sludge trucked away for disposal offsite.

4.3.3.4. Groundwater Levels

During utilization, geothermal fluid (hot water mixed with steam) would be routed to high- and low-pressure separators. Steam would be routed to the power plant. Hot water remaining after steam separation would be routed to the injection pumps and injected directly into the geothermal reservoir. Each well pad would be equipped with injection pumps, which would propel wastewaters to injection wells at yet-to-be-determined locations. Three to five injection wells would be used to inject geothermal fluids back into the geothermal reservoir at a depth of about 1,830 to 2,743 meters (6,000 to 9,000 feet). In accordance with Federal and state regulations, the casings of the injection wells would be sealed so that no injected fluid could enter groundwater bodies within 610 meters (2,000 feet) of the surface. Each well pad would also have a clay-lined sump into which fluids would be directed during the time it takes to shut off the wells in an emergency. If an emergency occurred and injection capacity were to be temporarily unavailable, spent geothermal fluid from the production wells would be routed to the sumps. No wastewaters would be disposed to either surface waters or shallow groundwaters; consequently, there would be no effect on surface or groundwater quality. As previously described, plans for sumps and the different disposal methods are subject to approval by the Oregon Department of Environmental Quality and must meet Oregon's antidegradation of natural waters policy.

Geothermal utilization could affect groundwater levels in two ways. The extraction and injection of geothermal fluids and the possible withdrawal of groundwater for the power plant cooling system could both affect groundwater levels. The proposed geothermal production wells are expected to be 1,830 to 2,743 meters (6,000 to 9,000 feet) deep. The extracted geothermal fluids would be a mixture of steam and hot water. Approximately 9.46 million cubic meters (7,670 acre-feet) of brine would be extracted annually. It is expected that 7.51 million cubic meters (6,068 acre-feet) of the fluid extracted would be injected back into the geothermal reservoir. The reinjected fluids would be derived from the low pressure separator and cooling tower blowdown. The remainder of the produced fluid, approximately 1.9 million cubic meters (1,580 acre-feet) per year, would be lost to the atmosphere by evaporation in the power plant cooling towers (Dames & Moore, 1994). This is roughly equivalent to the amount of water used annually by 2,570 typical households.

The net loss of 1.9 million cubic meters (1,580 acre-feet) per year of fluid from the deep geothermal reservoir could potentially affect caldera and regional groundwater levels. However, as noted in Section 3.4, Geothermal Resources, the shallow geothermal system in the caldera does not appear to be directly connected to the deep geothermal reservoir, so no effect on groundwater levels in the caldera would be expected (Dames & Moore, 1994). Effects on the geothermal reservoir are also addressed in the geothermal resources section.

The strata that the geothermal production and injection wells would penetrate are believed to lie at a depth below the ground surface of 1,830 to 2,743 meters (6,000 to 9,000 feet); that is between an elevation of approximately 304.8 meters (1,000 feet) above sea level and an elevation of 609.6 meters (2,000 feet) below sea level. Drinking water wells to the north and west of the proposed project site obtain water from a variety of water-bearing deposits at elevations of about 915 to 1,220 meters (3,000 to 4,000 feet) above sea level. A zone of low-permeability volcanic deposits, the John Day and Clarno Formations, lies between the shallow water-bearing deposits and the geothermal reservoir. It appears unlikely that groundwater in the shallow water-bearing deposits is directly connected to the geothermal reservoir. Thus, a small annual net loss of water from the geothermal zone would not be likely to affect regional groundwater levels.

The project proponent has filed a water rights application with the Oregon Department of Water Resources for 3.08 million cubic meters (2,500 acre-feet) per year of water to be obtained from wells that draw from the relatively shallow aquifers that overlie the geothermal reservoir. Although the power plant would be designed to produce most of its required operating water, the supplementary water source would be used to supply cooling system make-up water and to increase the amount of water returned to the geothermal reservoir through injection. Injection is desirable because it would help to maintain the pressure in the reservoir and extend its useful life. Withdrawal of 3.08 million cubic meters (2,500 acre-feet) per year at the proposed project site would not be likely to substantially affect regional groundwater levels, because the withdrawal would be small compared to total groundwater recharge of 276 million cubic meters (224,000 acre-feet) per year on the western slope of Newberry Volcano. Some local decline in groundwater levels and flow patterns would be expected. Existing wells would not be affected, because they are either several kilometers downstream of the site, or about 3 km (1.8 miles) upstream and isolated in the caldera. All water withdrawal requirements would be subject to approval by the Oregon Department of Water Resources.

4.3.3.5. Power Plant Cooling Water

Steam from the geothermal wells would be piped to the power plant where it would be used to drive a turbine, which would, in turn, drive the electrical generator. Spent steam from the turbines would be converted to water and then be used for cooling. The cooling system would consist of an evaporative cooling tower and a condenser. Water would circulate continuously in the cooling system. The cooling tower would be an approximately four-story- high structure resting on a concrete basin. Fans mounted on the top of the tower would draw air upwards, through the structure, while water trickles down through it. Cooled water would collect in the cooling tower basin and be pumped through the condenser. In the condenser, spent steam would pass over pipes containing cool water. The steam would be condensed and its heat would be transferred to the cooling water. The cooling water would then be recirculated to the top of the cooling tower.

Water must be added to the recirculating cooling system to replace that lost by evaporation. Condensate, spent steam converted to water, would be used as the water supply for the power plant cooling system. In order to prevent buildup of salts, some water would be drained from the recirculating cooling system. This water, referred to as cooling tower blowdown, would be discharged to the water storage pond. The water storage pond would be lined and would have a capacity of 1.36 million liters (360,000 gallons). Accumulated water in the pond would be injected into the geothermal reservoir.

Under cold weather conditions, it is expected that more condensate would be produced than would be needed for cooling system make-up water. Any excess water would accumulate in the cooling tower basin and would be routed to the water storage pond. Thus, the only wastewaters produced by the power plant would either be evaporated or injected into the geothermal reservoir. Consequently, there would be no effects on surface or shallow groundwater quality from routine discharge of wastewater.

The water storage pond would be equipped with two level-controlled pumps which would pump water from the pond to the injection wells. In the unlikely event that pond and pumping capacity were to be exceeded, the pond water would overflow, through an engineered overflow structure, to the ground surface. Because the local soils are very permeable, it is unlikely that water overflowing from the pond would proceed far before percolating into the ground. Water in storage ponds would be primarily condensate and thus would be unpolluted or, at worst, would contain small amounts of geothermal condensate constituents and the chemical additives used to control algae growth in the cooling system. An overflow from the pond would only occur in the event of an equipment failure. No significant adverse effect on groundwater quality would be expected from pond overflows that last only a few hours or days. It is unlikely that overflows would continue for more than a few hours before the equipment failure was corrected or flow halted.

4.3.3.6. Air Pollutant Deposition

Air pollutants emitted during power plant operation and associated well development and testing would be carried downwind of the site. Some of these pollutants would be deposited on the ground where they could eventually contribute to water pollution. Modeling studies were undertaken by SAIC (1993) and AGI (1994) to determine whether these emissions would have a significant adverse effect on water quality in Paulina and East Lakes. SAIC compared predicted concentrations of various substances present in the top 0.3 meter (1 foot) of lake water due to air pollutant deposition with EPA's and DEQ's water quality criteria. Appendix F-5 contains additional information on the modeling studies.

SAIC made a number of simplifying and conservative assumptions in order to model the potential deposition of air pollutants in Paulina and East Lakes. These are that emissions would be similar to those at other geothermal plants, that all metals and other elements were solubilized or in suspension and transported to the lakes, and that in the lakes they were mixed with the upper 0.3 meters (1 foot) of water. These assumptions represent a worse case scenario, in that some portion of each constituent is likely to remain in the soil or be deposited with sediment on the lake bed and uniform mixing is likely to occur within the lakes.

The results of the SAIC modeling indicated that increased concentrations for all metals and other elements, except for mercury, were significantly below federal drinking water standards and water quality chronic criteria. Values for mercury were below drinking water standards but identical to the water quality criteria. In a follow-up study by AGI Technologies, several lake mixing models were utilized to investigate the effects of mixing on mercury, arsenic, and boron concentrations in the lakes.

The more sophisticated AGI modeling (Appendix L) assumed the lakes were uniformly mixed because they undergo seasonal overturn that extends to the lake beds, and East Lake discharged to Paulina Lake through ground water, and Paulina Lake discharged through Paulina Creek. The mixing models were run for 500 years to determine concentrations at the end of the anticipated 50-year project life and at equilibrium. This more realistic modeling shows:

a. Mercury concentrations would be between 14 percent and 30 percent of the chronic criteria at 50 years and less than 35 percent at equilibrium in 200 years.

b. Arsenic concentrations would be less than 0.00008 percent of the chronic criteria at 50 years and less than 0.0009 percent at equilibrium in 200 years. Even though current baseline arsenic concentrations are above the 10^{-6} carcenogenic human risk level, the incremental increases of arsenic concentrations after 50 years will be only

0.0075-percent of the average baseline arsenic level in Paulina Lake and 0.0046-percent of the average baseline arsenic level in East Lake.

c. Boron concentrations would be less than 0.03 percent of the mean boron concentration in surface waters of the U.S. at 50 years and about 9 percent at equilibrium in 200 years.

The effects of these increases on wildlife are addressed in Section 4.12.

Mercury concentrations in the lakes would be increased by less than 0.00000319 mg/l over the 50-year project duration of the project. The fresh water chronic criteria for mercury is 0.000012 mg/l, which is nearly 4 times greater than the anticipated increase. The federal drinking water standard for mercury is 0.002 mg/l, which is 627 times higher than the anticipated increase. Should the mercury concentrations in the lakes be near the USGS detection level of 0.0001 mg/l, the estimated mercury contribution represents about a 3 percent increase.

If the mercury concentrations in the lakes exceed the chronic criteria value established in Oregon, then a new criteria would be established by the State to account for the elevated natural levels in the lakes. The lakes and Paulina Creek would then be labeled as water quality limited by the State of Oregon, which would require additional protections to minimize any increased inputs to the aquatic system.

The project requires a permit from DEQ for both air emissions and water emissions. Through this permitting process, the determination will be made by DEQ whether any additional mitigation measures are needed to protect the aquatic environment.

Mitigation measures will be used to reduce mercury emissions from the operating power plant. Mercury in gaseous form will be removed from the power plant emissions prior to release to the atmosphere. Removal is a two-step process involving an activated carbon adsorption system and a sulferox removal system. Together these systems operate at 98+ percent efficiency using one carbon unit. Additional units can be added, raising this efficiency level if the mercury content of the geothermal resource necessitate this additional mitigation measure. Mercury levels would be monitored at the sulferox stack and at the cooling tower to document levels of mercury emissions.

Arsenic concentrations in water samples collected by the US Geological Survey between October 1991 and September 1993 were around 0.015 mg/l in Paulina Lake and Paulina Creek and 0.003 mg/l in East Lake (Crumrine and Morgan 1994). Federal drinking water standards maximum contaminant level (MCL) for arsenic is 0.05 mg/l, and fresh water chronic criteria for arsenic is 0.19 mg/l. The existing arsenic concentrations are below these standards. However, the 10^{-6} carcinogenic human risk criteria for arsenic has been published as 0.0000022 mg/l. Clearly the existing arsenic levels in water samples, as determined by the USGS, are above this risk criteria. To assess the potential impact of arsenic contributions from the proposed development on the lakes, the anticipated arsenic contribution was uniformly mixed with lake waters in various models to estimate the increased concentration over the 50 year project duration (Appendix L). At the end of 50 years, the maximum increase in arsenic concentration is estimated to be 0.00000113 mg/l for Paulina Lake and 0.000000137 mg/l for East Lake. As can be seen, these incremental increases are insignificant over baseline values and will not adversely affect either the aquatic ecosystem or its fisheries.

Boron concentrations in the lakes are between 0.85 and 1.00 mg/l (Crumrine and Morgan 1994). No standards have been set for boron, but the average concentration in surface waters in the U.S. is around 1.0 mg/l, and the maximum concentration is around 5.0 mg/l. The mixing models, similar to those for mercury and arsenic, indicate that boron concentrations should increase by less than 0.0000269 mg/l over the 50 year project life. This amount is so small that boron concentrations in the lakes will remain below the national average. According to these data and calculations, boron contributions from the proposed development are unlikely to pose significant impacts to either the aquatic ecosystem or its fisheries.

4.3.3.7. Chemical and Hazardous Material Spills

Hazardous materials are addressed in detail in Section 4.14. Various potentially hazardous materials and chemicals would be used at the geothermal facility site. They include diesel fuel, lubricating oils, chemicals to control scaling and corrosion in the injection system, and chemicals to maintain water quality in the cooling system. All tanks containing these and any other hazardous substances would be installed above ground and provided with secondary containment. Secondary containment would consist of a curbed or bermed area around the tank, draining to a sump equipped with a valve. The valve would normally be in a closed position. The secondary containment would have a volume equal to 100 to 150 percent of the maximum spill volume. If a tank were to rupture, the spilled material would be confined within the secondary containment. It could then be cleaned up or recovered. Precipitation falling within the secondary containment areas would be retained in the sump and, if uncontaminated, discharged to the water storage pond. No spilled material would 'eave the well pads or power plant site, and thus there would be no adverse effects on water quality. An Emergency Contingency Plan would be established in the case of accidental spills or discharges. All drilling fluids would be formulated from "non-toxic" components and drilling effluents would be below EPA-defined end-of-pipe toxicity limits.

4.3.3.8. Decommissioning

Decommissioning would involve removal of all equipment and structures from the site. The site would be regraded and the original contours would be restored. Any wastewaters at the site would be injected into the geothermal reservoir before decommissioning the injection wells. Disturbed areas would be revegetated. Short-term adverse effects on water quality, similar to those described for construction activities, could occur during decommissioning. The adverse effects would be eliminated, or lessened, by adoption of proper construction procedures.

4.3.4. Effects Specific to Alternative A

The effects of Alternative A are common to Alternatives A and B and are described above in Section 4.3.3.

4.3.5. Effects Specific to Alternative B

Under Alternative B, the changes in water quality and hydrologic patterns could be more widely distributed than under Alternative A, depending on the choices of sites for the power plant, production wells, and other facilities. The additional mitigation measures incorporated into Alternative B would reduce the risk of water pollution somewhat during construction.

4.3.6. Additional Mitigation Measures That Could Be Applied to Alternatives A or B

Mercury levels in air emissions could be monitored. In addition, analysis of Newberry lakes fish tissues for mercury could be periodically conducted. If high levels of mercury emissions are found, additional mitigation measures, such as additional emission control systems or measures, could be implemented. In the extremely unlikely event that private landowner drinking water supplies are contaminated by geothermal development activities, compensation such as replacement water supplies could be provided.

4.3.7. Effects of Alternative C

Under the no-action Alternative C, the effects associated with construction and operation of the proposed project would not occur.

4.4. GEOTHERMAL RESOURCES

4.4.1. Impact Overview

Because the impacts related to geothermal resource production are proportional to the amount of geothermal fluids produced and injected, the potential for an impact to occur and the magnitude of the impact would increase as the project proceeds from exploration through development to utilization. Production from a geothermal reservoir has resulted in a variety of impacts at other geothermal areas of the world. Potential impacts include land subsidence, increased or decreased hot springs flow, geothermal reservoir depletion, faster than predicted production declines, mixing of geothermal fluids with the regional aquifer waters, and cold water intrusion into geothermal production wells. Some geothermal areas have experienced gas bursts (Sigurdsson 1987) and steam eruptions (Bruno et al. 1992), considered unlikely at Newberry Volcano because the natural conditions that lead to such events appear to be absent. Most geothermal resource impacts are closely linked to site-specific hydrogeological conditions, making comparisons between geothermal areas difficult. Still, experience elsewhere provides a benchmark for comparison and evaluation of potential impacts to Newberry Volcano and the Project Area.

The Project Area is located over 3.2 km (2 miles) from the nearest thermal springs, located at Paulina Lake (Figures 3.3-1 and 3.3-2). Present knowledge of the geothermal reservoir is based on drilling results inside Newberry caldera. The Project Area is located outside of Newberry caldera. Drilling results from the Project Area show that geologic conditions are different than found inside the caldera. A geothermal reservoir has not been discovered outside the caldera, although drill holes have probed to depths over 1,200 meters (4,000 feet) below the ground surface. Drilling indicates the potential geothermal system is probably 1.6 km (1 mile) deeper outside the caldera based on temperature gradients in drill holes (Blackwell 1993).

4.4.2. Methods of Analysis

Experience at other geothermal fields was used to assess the possible environmental impacts that could result from tapping the Newberry geothermal reservoir and to develop mitigation. Geothermal development impacts have been addressed in several previous studies for the Geysers (Lake County 1989), Coso Known Geothermal Resource Area (McClenahan & Hopkins Associates 1986; and Lofgren 1986), and Newberry Volcano (Dames & Moore 1994). Scientific investigations over the past 15 years or so have yielded considerable knowledge about the geologic structure, hydrogeology, geochemistry, mineralogy, heat flow, and probable heat source underlying Newberry Volcano. An extensive list of references was carefully reviewed to understand what is known about the geothermal resource at Newberry Volcano. Although the volcano has been subject to extensive scientific investigation, the potential geothermal resource and flow regime is still not fully understood. To better evaluate the potential impacts on the geothermal resource, a number of professionals experienced in both the geology of Newberry Volcano and in geothermal energy were consulted about potential impacts.

Impacts of geothermal reservoir production and injection considered in this analysis include: (1) impacts on the surface thermal features in Newberry caldera, (2) impacts on surface waters and groundwater, and (3) impacts related to geothermal resource life expectancy. Water quality impacts are discussed in Section 4.3, Water Resources, and geologic hazards are discussed in Section 4.2, Geology and Soils. Most potential geothermal impacts apply equally to both Alternative A and Alternative B.

4.4.3. Impacts Common to Alternatives A and B

4.4.3.1. <u>Impacts on the Hot Springs in Newberry Caldera</u>

If there is a good hydraulic connection between the production zone in the Project Area (estimated at 1,830 to 2,743 meters [6,000 to 9,000 feet] depth) and the thermal features in Newberry caldera, surface thermal features could be affected by fluid withdrawals. Extensive research by university groups and the U.S. Geological Survey have not confirmed that deep geothermal reservoir fluids other than steam mix with the hot springs at East Lake and Paulina Lake or with production fluid from a depth of 932 meters (3,048 feet) in the Newberry 2 core hole (Figure 3.3-1, Newberry Group Site). The absence of chloride ion in the shallow thermal waters as well as chemical (oxygen) isotope data suggest that communication between shallow and deep zones is very weak. Researchers have discovered very little evidence that surface thermal features discharge fluids originating from a deep geothermal system, although the surface thermal features may be weakly connected to a deeper system via fractures. Because the geothermal reservoir system is apparently deep and largely within the caldera and because the communications of the underground flow pathways between the geothermal reservoir and the hot springs in the caldera area are apparently rather weak, possible geothermal fluid withdrawal effects on the hot springs are likely to be slight, subtle and long delayed. Possible effects could also be masked by greater variations in hot springs output due to natural causes.

Evidence from many lines of reasoning lead to the conclusion that production impacts on surface thermal features would be negligible. Arguments supporting this conclusion include:

- The weak hydraulic connection
- The much greater energy potential of Newberry volcano's geothermal resource compared to the 30 MWe proposed project (see Section 3.4.5, Geothermal Potential)
- Planned reservoir pressure maintenance via re-injection of most produced fluids (about 70 to 80 percent) into the producing formation
- Natural recharge from the regional aquifer
- Creation of the NNVM, which has put a significant portion of that potential resource out of bounds for geothermal exploration and production
- The distance between the proposed production zone at sea level and below versus the surface thermal features at 1,800 meters (6,000 feet) above sea level
- The production wells would be downgradient (at lower water table elevations) from the surface thermal features

Still, an impact to hot springs productivity in the form of either increased or decreased thermal activity cannot be entirely ruled out. Increased activity could occur if fluid production over time results in reduced reservoir pressures. This in turn could lead to increased subsurface boiling and more steam and noncondensable gas (carbon dioxide, nitrogen and others) flow to the surface. Increased flux, although unlikely based on geological considerations, could potentially lead to increasing temperature and flow rates in the thermal springs. Decreased flow, due to possible cold water influx to the shallow hydrothermal system, could cause the hot springs to cool or even dry up. Natural changes in the shallow hydrothermal system could cause either of these events to occur as well.

Monitoring of fluid chemistry and temperature at the hot springs, lakes, Paulina Creek and water wells should provide adequate data about any changes to the thermal springs (Dames & Moore 1994). Monitoring could include continuation of the USGS monitoring program and drilling of a monitoring well within the Project Area.

Geothermal surface manifestations vary naturally over time. For instance, hot springs may get warmer or cooler or dry up and reappear, due to natural causes. At Newberry Volcano, the natural range of variations is not known because routine monitoring only began in 1991. The presence of cemented beach and hot springs deposits near Paulina Hot Springs and altered tuff deposits near

East Lake Hot Springs attests to thermal activity at higher elevations in the past and indicates that natural changes in that activity have occurred. However, even small changes to surface features that are outside the range of natural discharge variations may be unacceptable to some concerned parties if these changes can be reasonably attributed to geothermal developments. In order to minimize possible impacts, changes in the geothermal reservoir system would be monitored and minimized during exploration and production in the Project Area and possible changes that might occur in the hot spring discharge areas would be monitored with reliable measurements under a program similar to the USGS monitoring program. Additional monitoring controls would be evaluated, such as installation of a monitoring well in the project area, establishment of a permanent survey line for ground deformation measurements, and installation of seismic monitoring equipment.

If the proposed geothermal project is approved, hydrologic monitoring would continue.

4.4.3.2. Impacts of Fluid Injection

Surface Waters. There are no surface waters in the area of the proposed development which could be directly impacted by operation of the facility (see Section 4.3, Water Resources), thus there are no anticipated impacts to surface waters as a result of power plant operations. As described in Chapter 2, excess produced water and condensate would be returned to the geothermal reservoir through injection wells. All surface discharges of produced geothermal fluids will be to lined holding ponds. The fluids in these ponds will be routed to the injection wells for disposal by injection back to the geothermal reservoir.

Regional Aquifers. Injection of geothermal fluids would be at depths of about 1,500 to 2,743 meters (5,000 to 9,000 feet), similar to production depths. Shallow cold water aquifers at depths less than 600 meters (2,000 feet), would be cemented off behind steel casing in all production and injection wells. Well casing would prevent lateral movement of injected waters toward the caldera geothermal features. As a result, the impact of injection on regional and local groundwater resources quality and availability should be negligible.

The injected fluids would likely have a higher total dissolved solids (TDS) content than that of the reservoir fluids, which might be about 3,000 to 7,600 ppm based on comparison to Medicine Lake test well fluids. The geothermal water after the second flash would have a TDS content about 10 percent higher than the produced fluid. Injected fluids will have a TDS concentration about 3 percent higher than the produced fluid because the geothermal water will be combined with the relatively pure circulating water from the cooling towers (the cooling waters would have a very low TDS concentration similar to regional groundwater). Groundwater may be used to supplement injection of produced fluids and enhance production.

Under both alternatives, 70 to 80 percent of the fluids withdrawn would be injected back into the geothermal system. The net fluid loss from the reservoir would be less than 1 percent per year. This conservative calculation assumes that there is no natural recharge and no steam condensate injection. In fact, natural recharge from the regional aquifer, combined with injection of 50 to 80 percent of the produced steam, should make up for over 50 percent of the fluid loss. Considering natural recharge and injection, net reservoir depletion could be below 0.5 percent per year. At the thermal areas, which are located over two miles horizontally and over one mile higher elevation than the Project Area, the drawdown effects are expected to be negligible.

4.4.3.3. Life Expectancy of the Resource

The geothermal potential of Newberry Volcano is discussed in Section 3.4.5, Geothermal Potential, and the potential impacts of geothermal production on regional hydrology are discussed in Section 4.4.3.2, Geothermal Resources, and above in Section 4.3.1, Impacts on Surface Waters and Ground Water.

The potential impacts to the life expectancy of the Newberry geothermal resource from the proposed project are not known, but may reasonably be expected to be limited to depletion effects in the Project Area. Considering the estimated size of the Newberry geothermal resource (200-2,000 MW) compared to the 30 MW Pilot Project, it seems reasonable to assume that production would be sustainable for the 50-year life of the power sales contract. This assumes that exploratory drilling confirms the existence of sufficient fluid reserves to deliver the necessary quantity of steam to the power plant. A lower recovery rate from the resource (Section 3.4.5, Geothermal Potential) than estimated would proportionally increase production-related impacts on geothermal resource life expectancy. Only exploratory drilling and testing can provide the information necessary to improve confidence that a sustainable geothermal resource exists in the project area. Production wells would be spaced to sustain field production.

4.4.3.4. Other Potential Impacts

Several other types of impacts have been observed at other geothermal areas around the world. These include ground subsidence and increased seismic activity. None of these potential impacts is likely to occur at Newberry Volcano, as discussed in Section 4.2.3, Geology and Soils.

Wastes, such as sanitary and chemical wastes, may contaminate ground or surface waters if not properly used, stored, and contained. Procedures for waste management are presented in Section 4.14, Human Health and Safety.

4.4.4. Impacts for Alternative A

Impacts for Alternative A are discussed above under Impacts Common to Alternatives A and B. No other impacts specific to Alternative A have been identified.

4.4.5. Impacts for Alternative B

Impacts for Alternative B are discussed above under Impacts Common to Alternatives A and B. No additional impacts are anticipated under Alternative B.

4.4.6. Additional Mitigation

Chemical monitoring of groundwater in the Project Area could help to verify the effectiveness of the casing program. A proposed monitoring well could be installed with the bottom of the well in the regional aquifer at about 1,280 meters (4,200 feet) elevation above sea level or about 500 meters (1,600 feet) below surface. The monitoring well would provide information on the depth of local and regional groundwater, allow baseline groundwater quality sampling before development, and provide a monitoring point during geothermal utilization. As with the hot springs, natural variations are expected in groundwater chemistry. Early installation and quarterly sampling and testing to establish baseline conditions could be conducted. A reduced monitoring program may be appropriate after baseline conditions are established.

Mitigation of geothermal production effects on the life expectancy of the geothermal resource is desirable. If significant adverse effects were identified, mitigation measures to maintain the production rates (and the life of the reservoir) would include:

- Increasing the quantities of injected fluids to maintain reservoir pressure and flow rate
- Modifying the injection program to reduce interference with production wells (if cold water intrusion is caused by injection)

4.4.7. Impacts for Alternative C

Geothermal resources development impacts would not occur under the no-action Alternative C. Information about the geothermal resource would not be gathered and the viability of geothermal power production at Newberry would not be tested.

4.5. CLIMATE AND AIR QUALITY

4.5.1. Impact Overview

Typical air quality impacts of geothermal development are associated with short-term construction dust and air emissions from the geothermal resource through well testing and power plant operation. The resource at Newberry is expected to produce steam and hot water. The steam phase is expected to consist of water vapor and chemical constituents entrained in the water vapor (i.e., minerals and noncondensable gases). The types of pollutants emitted are unique to the geothermal resource, but would be expected to include carbon dioxide (CO_2) (probably comprising between 95 to 98 percent of the total noncondensable gas) with smaller amounts of hydrogen sulfide (H_2S), and trace amounts of methane (CH_4) and ammonia (NH_3). There may also be trace amounts of elements such as mercury (Hg), boron (B), and arsenic (As) present. Emissions would be transported and dispersed by wind away from the plant and eventually deposited on land, vegetation, and water.

Emissions would occur during all phases of the project from well venting, normal operations of the power plant, and plant upset conditions. These emissions may (1) increase the level of pollutants in the air, including H_2S (rotten egg odor) near the facility, (2) affect visibility, (3) deposit heavy metals and trace elements that may have an impact on the ecosystem, and (4) create long-term impacts from emissions on nearby natural resources and sensitive receptors.

Of all the pollutants emitted, H_2S is of primary concern due to the fact it can be smelled at very low concentrations. Odor is the primary public concern for H_2S, as detection by smell will usually provide a "warning" at concentrations much below levels of health concern (see Section 3.5).

During unabated well venting, emissions of H_2S to the atmosphere would be expected at instantaneous concentrations of 80 to 400 ppm within the steam plume. Although this concentration is high enough to have adverse health effects under direct exposure, the plume is very buoyant and would dissipate quickly to lower concentrations (CEE 1992b). These lower concentrations could create nuisance odors under certain conditions, but would not be high enough to create adverse health effects.

Fugitive emissions caused by dirt and dust due to construction activities would be expected during the exploration, development, and decommissioning phases of the project. Emissions would be similar to other construction projects, and would include engine exhaust from drilling rigs, haul-trucks, workers commuting to the plant site, and road dust caused from traffic on unpaved roads and earth-moving activities. Road dust emissions would be greater during the drier months.

4.5.2. Method of Analysis

4.5.2.1. State and Federal Standards

Project-related air emissions were examined with reference to state and Federal emissions limits and ambient air quality standards and acceptable levels as discussed in Section 3.5.2.3. Additional information about air quality regulations can be found in Appendix E. In Oregon, implementation of the Federal Clean Air Act has been delegated to the Oregon DEQ. The proposed project would therefore be required to operate in accordance with conditions set by DEQ for air quality.

4.5.2.2. Background Air Quality

Background concentrations of pollutants were estimated from various sources considered representative of the proposed project site, including:

- Crater Lake National Park, and Three Sisters Wilderness Area
- Reports from typical western atmospheric levels
- Geological reports on soil chemistry
- Emission Inventory for Deschutes County and State of Oregon (DEQ)

Section 3.5.2 also describes these sources used for background concentrations at Newberry. These locations were selected to best represent the good air quality of the Newberry area because data on background levels were not available for the site.

4.5.2.3. Emission Estimates

Estimates used for types and quantity of expected emissions from the Newberry Project were obtained from comparable geothermal resources at Medicine Lake, California, Coso, California, and Desert Peak, Nevada. Data from Medicine Lake, also located within the Basin and Range region east of the Cascades, is the most similar to Newberry in four ways. The resources each have a similar (1) contemporary geologic origin (2) caldera structure, (3) volcanic origin, and (4) reservoir rocks. Coso and Desert Peak are also similar in that they are typical of Basin and Range volcanism. However, the Coso geothermal reservoir, located in southern California, contains more noncondensable gases than does the Medicine Lake resource, and represents the high end of the expected emission ranges. Coso data are expected to overestimate H_2S levels that would occur at Newberry. A certain degree of variability is anticipated between individual wells at Newberry; however, the data used from Medicine Lake, Coso, and Desert Peak all reflect average values among wells. Table 4.5.2-1 indicates the relative levels of H_2S emissions from these three geothermal resources:

Table 4.5.2-1 Unabated H_2S Emissions of Typical Western Geothermal Wells During Testing[1]

Location	H_2S (kg/hr)	H_2S (lb/hr)
Desert Peak, NV	0.59	1.30
Medicine Lake, CA	1.27	2.79
Coso, CA	7.62	3.46

[1]75 percent of maximum well capacity, assuming 181,440 kg/hr (400,000 lb/hr) well production.

Before air permits can be issued, actual resource data for Newberry would be available from testing results. If there is a large discrepancy with the data used in this EIS, new or additional modeling and environmental analyses may be required. The need for additional analysis would be determined by DEQ, the U.S. Forest Service, and BLM only after actual data were available for each well.

4.5.2.4. Air Quality Modeling

All air pollutants emitted by a source are transported and dispersed by meteorological and topographic effects. Any given location receives pollutants in varying amounts, depending on the prevailing winds, topography, and other meteorological factors. In order to estimate whether ambient concentrations of any selected pollutant at a given location would exceed allowable standards, mathematical models have been developed. These models simulate the behavior of pollutant plumes from air pollution sources.

Most EPA-approved regulatory dispersion models, such as those employed to analyze potential air quality impacts of the Newberry Caldera project, are "Gaussian" models. That is, these models assume that air pollutants emitted from a source dissipate in the horizontal and vertical directions in an exponential fashion. These models also assume dilution in the downwind direction as a function of wind speed. The rate of pollutant concentration decay in any direction will depend upon the meteorology (e.g., wind speed, atmospheric stability, and the vertical mixing height). Therefore, as in the case with the Newberry project, measured meteorological parameters representative of the area are input into the model to characterize the rate of pollutant dispersion. When combined with data on emission rates and characteristics of the emission release points, air pollutant concentration predictions can be made at specified points in the project area, called "receptors." The actual dynamics of atmospheric dispersion are extremely complex; thus, Gaussian models employ many simplifying assumptions in order to arrive at concentration predictions. These assumptions are generally considered to be conservative; that is, Gaussian models, as shown by EPA model validation studies, will generally overpredict actual air impacts.

The EPA-approved air dispersion models (Complex 1 and ISCST-2) were used to simulate impacts of expected emissions upon the study area (Figure 4.5-1). Meteorological data were collected over a one-year period by CEE at the proposed geothermal plant site (Alternative A) for use in the air quality modeling. Total atmospheric concentrations were estimated by adding the modeled values to typical background concentrations. Pollutant concentrations were determined for various receptor points, including locations within the caldera, the closest point to the NNVM boundary, a nearby bald eagle nest, the closest point to the Sisters Wilderness boundary, Sunriver, LaPine, and Bend (Figure 4.5-1). See Table 4.5.2-2, Appendix F-4 and F-2 for a description of all 18 sensitive receptors that were modeled.

Section 3.5.2.4 describes the pollutants that were modeled. Results of the computed concentrations were compared to Federal/state ambient air standards and allowable emission rates.

Visibility impacts to the Three Sisters Wilderness were estimated using the EPA-approved visibility model for PSD analyses, VISCREEN. See Appendix F-3 for a summary of the visibility impact modeling methods and results.

Effects of emission deposition on nearby sensitive receptors within the caldera were also modeled for assessment of potential lake water quality impacts in the NNVM. Results of this modeling can be found in Appendix F-5 and F-6 and a discussion of the potential impacts to ecological systems is contained in Sections 4.3, Water Resources, 4.12, Wildlife, and 4.11, Vegetation.

4.5.3. Effects Common to Alternatives A and B

The following section is divided into two major parts. The first part, Section 4.5.3.1, discusses the sources of emissions, and how emissions can or cannot be controlled. The second part, Section 4.5.3.2, presents the results of computer modeling which quantifies the impacts of emissions from the proposed project. Section 4.5.3.3 discusses global warming.

During the exploration phase, wells, well pads and roads would be constructed, and wells would be tested. Emissions during this phase would consist mainly of engine exhaust, road dust, and steam venting from the wells during drilling and testing.

During the development phase, emissions from construction of the power plant, roads, steam lines, transmission lines, and production wells would be limited to construction-related impacts such as vehicular exhaust and dust. Some well testing would continue during the development phase. With appropriate mitigation, construction during the development phase is not expected to result in violation of applicable air quality standards.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Location of Sensitive Receptors Used in Refined Modeling	Figure 4.5-1

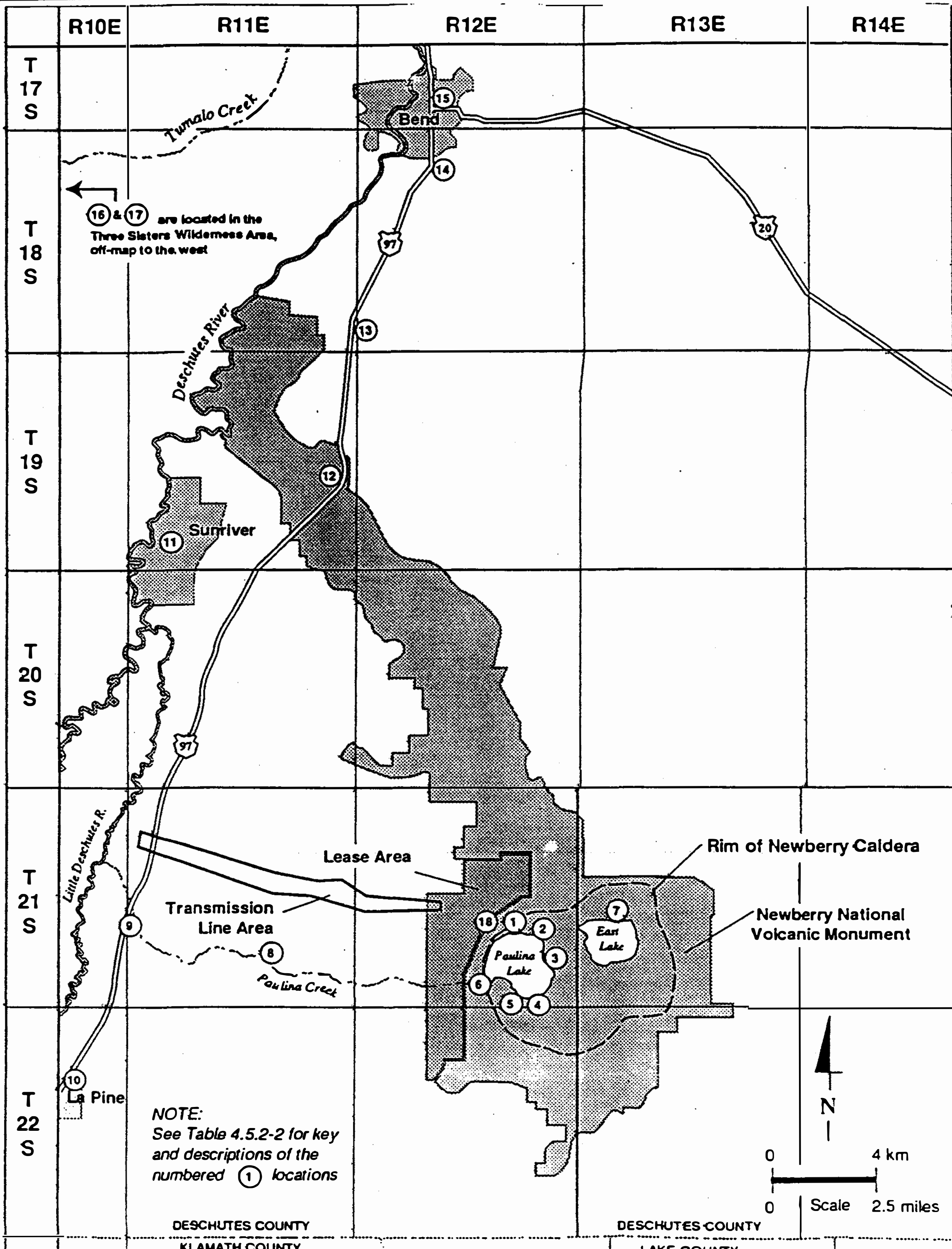


Table 4.5.2-2 Listing of Sensitive Receptors Used in Refined Modeling

No.	Receptor Name	Description	Distance* Km (mi)	Township / Range	Section
1	CAMP1	North Cove Campground, north of Paulina Lake	3.0 (1.9)	21S/12E	26
2	CAMP2	Warm Springs Campground, northeast of Paulina Lake	4.2 (2.6)	21S/12E	25
3	CAMP3	Little Crater Campground, southeast of Paulina Lake	5.2 (3.2)	21S/12E	36
4	HOUSES	Summer houses, southeast of Paulina Lake	5.3 (3.3)	21S/12E	36
5	CAMP4	Camp/houses at south end of Paulina Lake	4.8 (3.0)	21S/12E	35
6	LODGE	Paulina Lodge, west end of Paulina Lake	3.1 (1.9)	21S/12E	34
7	BE-NEST	Bald Eagle nesting area, north of East Lake	7.0 (4.3)	21S/13E	19
8	MCKAY-CROSS	McKay Crossing Campground, 5 miles west of Paulina Lake	6.8 (4.2)	21S/11E	19
9	RESIDENCE	Residential area at intersection of 97 and 21	12.6 (7.8)	21S/11E	35
10	LAPINE	LaPine, Highways 97 and 22	18.0 (11.2)	22S/10E	14
11	SUNRIVER	Sunriver residential area, 11 miles north of LaPine	15.0 (9.3)	20S/11E	19
12	LAVA-VISIT	Lava Lands Visitors Center, 13 miles north of Paulina Lake	19.5 (12.1)	19S/11E	24
13	HD-MUSEUM	High Desert Museum, 6 miles south of Bend	25.5 (15.8)	18S/12E	31
14	BEND-1	Nearest Bend subdivision, 3.5 miles south of Bend	30.0 (18.6)	18S/12E	18
15	BEND-DT	Downtown Bend, Highways 97 and 20	36.0 (22.4)	17S/12E	33
16	CLASSI-N	Nearest Three Sisters Wilderness Area boundary, 15 miles west of Bend	43.5 (27.0)	17S/09E	36
17	CLASSI-S	Second-nearest Three Sisters Wilderness Area boundary, 21 miles northwest of LaPine	44.5 (27.6)	20S/08E	12
18	MONUMENT	Nearest Newberry Crater National Volcanic Monument boundary, west of Paulina Lake	1.7 (1.1)	21S/12E	22

* Distance from the proposed plant site.

During the utilization phase, emissions would be generally split into two classes: well field emissions and power plant emissions. The power plant design would include processing of noncondensable gases to control emissions of H_2S.

Emission points within the power plant during operations are:

- The liquid redox H_2S control system vent
- Steam venting through the power plant steam vent silencer
- The cooling tower

Emissions for all regulated pollutants during the worst-case scenario for the project and emissions during typical operations are expected to result in impacts well below applicable state and Federal standards set to protect human health and welfare (Section 4.5). The following regulated pollutants were modeled for impacts (see Appendix F-2 and F-4 for more information):

particles less than 10μ (PM_{10})	cobalt (Co)
sulfur dioxide (SO_2)	manganese (Mn)
carbon monoxide (CO)	mercury (Hg)
ozone (O_3)	nickel (Ni)
nitrogen dioxide (NO_2)	selenium (Se)
lead (Pb)	radon-222 (Rn-222)
antimony (Sb)	boron (B)
arsenic (As)	hydrogen sulfide (H_2S)
beryllium (Be)	ammonia (NH_3)
cadmium (Cd)	volatile organic compounds (VOC)
chromium (Cr)	total suspended particulates (TSP)

4.5.3.1. Sources of Emissions

Engine Exhaust. Diesel or gasoline engines would be used to power the drilling machinery and vehicles. All diesel or gas-driven equipment would be equipped with mufflers. All equipment would be maintained to ensure compliance with applicable Federal standards. Motor vehicles would be restricted to established roads and equipment operations would be limited in duration (CEE 1992a). CEE has proposed a moderate-sized vehicle and equipment fleet during construction, which would not add substantially to the levels that exist in the region from other sources such as highway travel, forestry practices, and recreational activities. Construction-related vehicular exhaust emissions are not expected to result in any violation of air quality standards. These emissions would occur throughout the life of the project, but would be greatest during construction. Mitigation measures which would help reduce impacts of engine exhaust include turning off vehicle and equipment engines when not in use and carpooling between construction crews to limit the amount of vehicular emissions.

Road Dust. Construction and road dust would be emitted during dry, precipitation-free weather. Federal and state ambient standards for particulates may be temporarily approached near construction sites and access roads under some circumstances such as high winds and vehicle activity periods.

Dust would be emitted during exploration due to road construction and construction of well pads. Also, use of the roads for hauling equipment and construction personnel would contribute to the levels of particulates in the air. During development, construction of the steam lines, transmission lines, power plant, and additional access roads for these facilities would continue to contribute to background levels of dust. During utilization, dust emissions would be minimized and associated with maintenance of production wells.

Modeling of these fugitive emissions demonstrated that with control efficiencies ranging from 40 to 60 percent (achieved by a watering program or other means) during the exploration and construction phase, Federal and state ambient air standards would not be exceeded at any of the sensitive receptors. Results of this modeling are contained in Appendix J.

Well Field Emissions. Well field emissions would occur during the exploration and development phases when wells are vented to the atmosphere during well drilling and well testing as well as during the utilization phase, although to a lesser degree. Results of air quality modeling which show the impacts of well field emissions are contained in Appendices F-4 (for H_2S) and F-2 (for all other pollutants). The manner in which the impacts were modeled is discussed in the following section, 4.5.3.2. Well field emissions are considered together with plant operations in order to determine the maximum impacts of multiple emission sources. For a description of well field emissions, see Appendices F-2 and F-4.

Well field emissions would occur when geothermal fluids and gases are directed through a well-head silencer, which reduces noise and separates the liquid from the steam and steam from the well-head silencer would be vented to the atmosphere. Well venting can last up to 90 days at a time per well, and would occur during the exploration and development phase. Well venting would occur less frequently during the utilization phase as replacement wells are drilled and tested.

During well drilling, emissions would occur once the geothermal resource is encountered and begins to flow. Once a well is initially drilled, it is typically tested and allowed to vent to the atmosphere for a few hours to establish initial flows and to clean out any drilling mud remaining in the well. Longer tests (up to 90 days) would be required to test reservoir characteristics and well performance in the early stages of exploration; tests would become shorter in duration as more information is gathered about the resource.

Well field emissions also would occur during the utilization phase for well maintenance, in the event of a power plant upset condition, and as replacement wells are drilled and tested. Emissions during well maintenance occur throughout the life of a well to clean out rocks and any corrosion that may build up. This may occur as frequently as once per year, and as infrequently as once every 10 years. The frequency depends upon the chemistry of the geothermal resource.

Wells would be shut-in (flow would be reduced or stopped) during an upset condition when emissions from the power plant must be reduced. The wells would be shut back as quickly as possible without damage to the well. If necessary (i.e., during a life-threatening emergency), wells could be shut-in within 60 seconds, but that could cause casing collapse or other dangerous conditions. During an upset condition, wells would be shut back gradually. After one hour the wells would be shut back 50 percent; after 6 hours they would be shut back to 25 percent of full flow.

When well flow to the turbine is stopped, wells would usually be allowed to vent a small amount of steam through the well-head silencer. This is called bleeding, and it keeps the piping system hot and allows for an easy restart. During well maintenance and well bleeding, steam would be vented to the atmosphere through the well head silencer.

Power Plant Emissions

- Liquid Redox Vent. During normal operations, most of the noncondensable gases from geothermal steam production would flow with the high-pressure steam and be piped to the emission control system (Figure 4.5-2). H_2S would be removed before other noncondensable power plant gases, such as carbon dioxide, are vented. It is anticipated that the noncondensable gases will not require further abatement prior to release through the vent, with the exception of mercury, as discussed below.

The proposed project would employ a liquid redox system, such as a "Sulferox" system, for H_2S removal. Alternative technologies including: (1) incineration, (2) compression and injection, and (3) Stretford vanadium reduction system were evaluated. The incineration technology was not selected because it requires a high amount of methane gas for operation. The compression and injection system was not selected because experience with similar systems has shown a high amount of down time creating uncontrolled venting and injection of the gas back into the reservoir can often lead to gas breakthrough to the production wells causing complete failure of the entire production system. The Stretford vanadium system was not selected because the vanadium contaminated sulfur cake by-product is a hazardous waste.

If mercury is present in the noncondensable gases, a charcoal filter system (activated carbon) would be placed before the liquid redox system to remove mercury. Mercury would be removed because it can render the sulfur "cake" (a solid sulfur product used in agricultural applications) unmarketable and because it is an air pollutant. The filter would lower the amount of mercury emissions substantially. The measured mercury removal efficiency of the charcoal filter system at the Coso geothermal facility is 97.7 percent. If necessary, additional filters can be added to increase the efficiency. For purposes of modeling the depositional impacts of accumulated power plant emissions, a 97.7 percent reduction in expected Hg levels was assumed (see Appendix F-5).

- Steam Venting. During certain situations, the liquid redox system would be bypassed and steam vented without H_2S treatment. This is called steam venting through the power plant silencer. During steam venting, geothermal steam is emitted directly to the atmosphere, similar to venting through the well-head silencer.

Steam venting at the power plant would occur during start-up and shut-down of operations, and during unplanned outages. A cold start-up takes 12 to 24 hours. Planned shut-down takes about 3 to 5 hours. Unplanned outages, as a result of a break down or upset conditions, results in similar venting. The majority of such shut-downs would be remediated within a few hours. Generally, the control of venting at the power plant during upsets or breakdowns is achieved by reducing the amount of incoming steam from the wells.

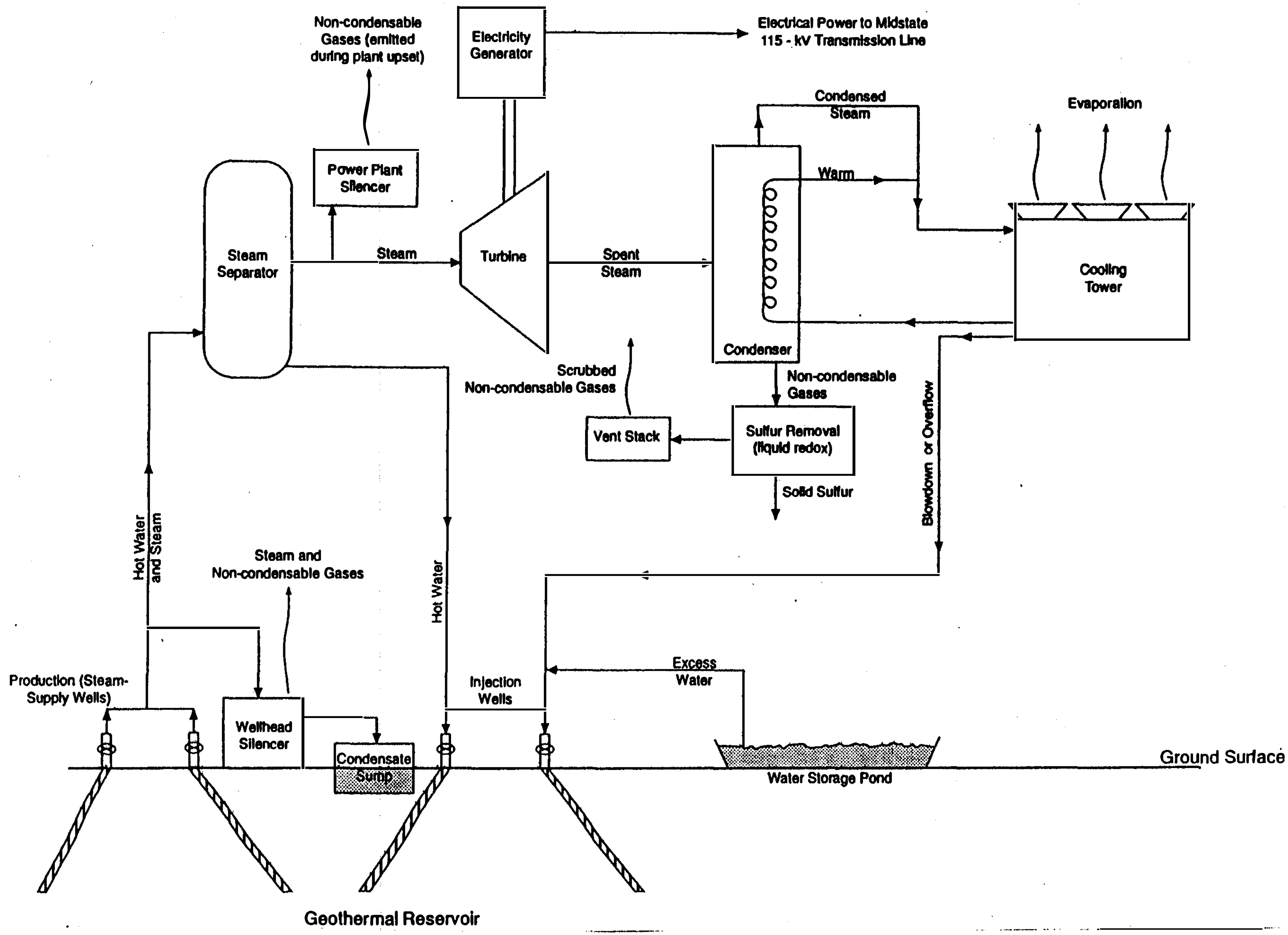
If the breakdown or upset condition could not be fixed during the first six hours, venting would have to be decreased in order to meet emission standards or the wells must be closed. Control plans would be negotiated with the agencies and DEQ after reservoir data have been compiled and adequate interpretation has occurred to understand how the wells would react to closure or start-up.

Other than the emergency back-up system and a controlled reduction in the amount of steam, there is no practical control technology available to abate emissions from steam venting at the power plant silencer. Since levels of emissions are expected to be low, alternative control technology was not proposed and will not be considered within the EIS.

- Cooling Tower. During normal plant operations during the utilization phase, geothermal liquids are exposed to the atmosphere when geothermal steam condensate is sent to the cooling tower as make-up water. Condensers which provide maximum separation of noncondensable gases from steam would be utilized. Emissions of liquids and dissolved minerals would occur when moisture is evaporated from the cooling tower.

Simplified Flow Diagram of Newberry Geothermal Project

Figure 4.5-2



Fine droplets of cooling tower water would be released from the cooling towers, entrained with air and water vapor. These droplets are referred to as "drift", and would contain constituents of the cooling tower water. The cooling tower would be recharged with condensed steam, with noncondensable gases removed. This condensed steam will be low in dissolved solids. The vapor drift would disperse in the air and, over time, would settle to the ground.

The cooling tower would be sited to maximize the dispersion of its emissions. Recirculation of cooling tower waters would be controlled to minimize build-up and emission of dissolved solids, including: sodium, chloride, sulfate, potassium, boron, lithium, fluoride, mercury, and bicarbonate. The use of surface (rather than direct contact) condensers will minimize emissions of chemical constituents from the cooling towers.

4.5.3.2. Air Quality Impacts

Four plant operational scenarios were considered and modeled to assess the effects on air quality. These scenarios are based upon the project proposal in Alternatives A and B, which states that no more than two wells will be venting at any given time for testing or maintenance reasons. The venting and testing would occur during exploration. Six wells producing 6 MW per well (actual number of wells may be more or less but would produce emissions at the same rate) would be required to provide 30 MW of energy (during utilization). During a plant upset, emissions from the six wells would temporarily bypass the liquid redox sulfur control system and be directly emitted through the plant silencer into the atmosphere. The worst-case scenario would be a plant upset while two test wells were venting.

The four scenarios modeled are:

Scenario 1. Plant normal operation, including emissions from cooling tower and liquid redox system (two sources).

Scenario 2. Normal operation plus two wells venting into the atmosphere (four sources). The two wells closest to the plant were selected for Scenario 2.

Scenario 3. Two wells venting into the atmosphere, but no power plant operations (during drilling).

Scenario 4. Plant upset conditions with six wells venting through the power plant silencer plus two wells venting through the well-field silencers. This scenario also has three sub-scenarios, to represent the fact that during an upset condition, after one hour the wells would be shut back to 50 percent of full production flow; after 6 hours they would be shut back to 25 percent of full flow. If after the second reduction other significant air quality problems persist, the wells would be shut back further to prevent further problems. To simulate the various states of the upset control conditions, modeling was conducted as follows:

- Full emission rate starting at time 0-hours (1-hour duration)
- 50 percent emission rate starting at time 1-hour (5-hour duration)
- 25 percent emission rate starting at time 6-hour

Table 4.5.3-1 shows a summary of the H_2S concentrations at eight of the representative receptors during normal operations (Scenario 1) and during an upset condition (Scenario 4). Appendix F-4 contains the complete results for 18 receptors and all four scenarios. These results represent the expected concentrations of H_2S during an upset condition under atmospheric conditions of least dispersion. Such atmospheric conditions would occur about 5 percent of the time (see Appendix F-4).

The odor threshold for H_2S for most individuals is 4.6 $\mu g/m^3$. This value would be exceeded only during upset conditions, and only at the three closest receptors that were modeled. Under the normal operating scenario during the most frequent daytime and nighttime sets of wind speed, wind direction, and stability class showed that concentrations of H_2S at all receptors would not exceed 0.1 $\mu g/m^3$ (See Appendix F-4). Therefore, it is very unlikely that H_2S odors would be detected during normal operations.

Table 4.5.3-1 Hydrogen Sulfide (H_2S) Concentrations During Normal Operations and Upset Conditions*

Receptor	Distance from Proposed Project	Scenario 1: Normal Operations	Scenario 4: Upset Conditions Concentration in $\mu g H_2S/m^3$ (0 hr)	(1 hr)	(6 hr)
Nearest NNVM boundary	1.7 km (1 mile)	0.1	69.0	34.5	17.2
Paulina Lake Lodge	3.1 km (2 miles)	0.1	28.7	14.4	7.2
Camp 1 (North Cove Campground)	3.0 km (2 miles)	0.01	29.4	14.7	7.3
Camp 2 (Warm Springs Campground)	4.2 km (3 miles)	0.0	19.2	9.6	4.8
Camp 4 (south end of Paulina Lake)	4.8 km (3 miles)	0.1	18.7	9.4	4.7
Nearest Bald Eagle Management Area	7 km (4.3 miles)	0.0	1.9	0.9	0.5
Sunriver	15 km (9.3 miles)	0.0	1.2	0.6	0.3
LaPine	18 km (11 miles)	0.0	0.9	0.4	0.2
Nearest Class 1 Boundary (Three Sisters Wilderness Area)	43.5 km (27 miles)	0.0	0.3	0.2	0.1
Bend	30 km (19 miles)	0.0	0.7	0.4	0.2

Standards: California = 41.7 $\mu g/m^3$ (30 ppb)
Odor threshold = 4.6 $\mu g/m^3$ (3.9 ppb)
No Federal or Oregon State H_2S standards.
* *Source*: SAIC, 1993. See Appendix F-4.

Table 4.5.3-1 also indicates that at the beginning of an upset condition, the concentration of H_2S at the closest receptor (the nearest point to the NNVM boundary) would exceed California's odor-based standards, but not at any other receptor. (The California standard is referenced because there is no Federal or Oregon State standard for H_2S.) This location is a remote, uninhabited site about 1.4 km (0.9 miles) from Paulina Lake Lodge. The impact at Paulina Lake Lodge, which is the nearest continually occupied site, is 60 percent lower than at the nearest NNVM boundary and within the California H_2S standard. The concentration of H_2S decreases rapidly the further from the source. After the first hour, the concentration of H_2S would be below the California standards.

The probability of a plant upset occurring which would cause the California standard to be exceeded at the nearest sensitive receptor is 0.27 percent. The probability of a plant upset condition occurring during the same time as the worst meteorological conditions (i.e., calm conditions) which would cause the California standard to be exceeded at the nearest sensitive receptor is 0.014 percent (see Appendix F-4). This probability is equivalent to about one hour per year. This value is a conservative estimate, since the occurrence of an upset is not statistically independent of meteorological conditions. Severe conditions such as wind storms, ice storms, thunderstorms, and snowstorms could cause the plant to shut down, producing an upset. Generally, severe meteorological events such as these produce good atmospheric dispersion conditions (which would reduce H_2S concentrations). In addition, well venting would not be conducted during periods of inclement weather and deep snow cover.

Table 4.5.3-2 shows a summary of the mean annual emission rates for each significant pollutant. These emission rates are compared to applicable standards. These annual rates are based upon the expected number of upsets that would occur during one year. Appendix F-6 contains the complete results and a discussion of methods used. The emission levels are well below the applicable standard of 250 tons per year which would require a PSD permit, and are also below Oregon's toxicity standards known as Significant Emission Rates. (See Appendix E for a discussion of regulatory compliance).

Table 4.5.3-3 shows the highest concentrations of various pollutants within the first hour of an upset condition at seven sensitive receptors. Although the impacts of geothermal emissions at all 18 sensitive receptors were determined, a representation of impacts at seven receptors of concern are shown. These seven receptors are:

(1) The closest boundary of the NNVM, located west of Paulina Lake, 1.7 km (1.1 miles) from the proposed power plant (Alternative A) (T21S/R12E, Section 22).

(2) Paulina Lake Lodge, west of Paulina Lake (3.1 km (1.9 miles) from power plant (T21S/R12E, Section 34).

(3) Camp 1, North Cove Campground, north of Paulina Lake, 3.0 km (1.9 miles) from power plant (T21S/R12E, Section 26).

(4) Camp 2, Warm Springs Campground, northeast of Paulina Lake, 4.2 km (2.6 miles) from power plant (T21S/R12E, Section 25).

(5) Camp 4, camp and houses at south end of Paulina Lake, 4.8 km (3 miles) from power plant (T21S/R12E, Section 35).

(6) Nearest Bald Eagle Management Area, nesting area located north of East Lake, 7 km (4.3 miles) from power plant (T21S/R13E, Section 19).

(7) The nearest boundary to the Three Sisters Wilderness Area (closest Class 1 area), located 43.5 km (27 miles) to the northwest (T17S/09E, Section 36).

Table 4.5.3-3 was prepared using the results from Appendix F-2. The results show that the predicted ambient concentrations are well below suggested standards, AALs, and PSD increments, except for radon-222, which was predicted to slightly exceed the AAL at the nearest boundary with the NNVM under worst-case emission and dispersion conditions (Scenario 4). It should be noted that although radon-222 is a carcinogenic gas due to its radioactive properties, it is not considered an outdoor air toxic hazard. There are no published outdoor cancer unit risk factors or acceptable exposure levels for radon-222. It is primarily of concern indoors where concentrations can build up over time and exposure to the gas is continuous. The slight exceedance of AAL standard is not considered significant for the following reasons: (1) the air pollutant would occur outdoors, (2) exposure would not be continuous, (3) the frequency of exceedance is rare, and (4) the area is remote and not occupied by people.

Table 4.5.3-2
Estimated Regulatory Air Pollutant Emission Rates and Mean Annual Total Masses

Pollutant	Chemical Symbol or Abbreviation	Source Full Emission Rate (grams/sec)[a]			PROJECT EMISSIONS			Significant Emission Rates (SER) for Oregon[c]	Significant Emission Rates for Criteria Pollutants
		Wellhead[b] Silencer	Sulferox	Cooling Tower	Average Annual Emission Rate (grams/sec)	Average Annual Emission Rate (lb/hr)	Average Annual Emission Rate (tons/year)	(lb/hr)	(tons/year)[m]
Hydrogen Sulfide	H_2S	0.3510	0.0046	0.0160	0.1006	0.8	3.50	3.2	10
Particles <10 µ	PM_{10}[d]	0.0390	0.0005	0.0050	0.0143	0.11	0.50	No SER[f]	15
Sulfur dioxide	SO_2[e]	0.664	0.0095	0.0309	0.1918	1.5	6.67	No SER[f]	40
Carbon monoxide	CO	trace	trace	trace	trace	—	—	No SER[f]	100
Ozone	O_3	trace	trace	trace	trace	—	—	No SER[f]	—
Nitrogen dioxide	NO_2	trace	trace	trace	trace	—	—	No SER[f]	40[l]
Lead	Pb	9.35×10^{-7}	1.19×10^{-8}	1.19×10^{-7}	3.42×10^{-7}	2.72×10^{-6}	1.19×10^{-5}	No SER[f]	0.6
Antimony	Sb	1.52×10^{-6}	1.95×10^{-8}	1.95×10^{-7}	5.58×10^{-7}	4.4×10^{-6}	1.94×10^{-5}	0.11	—
Arsenic	As	7.14×10^{-7}	9.15×10^{-9}	9.15×10^{-8}	2.62×10^{-7}	2.1×10^{-6}	9.11×10^{-6}	6.8×10^{-4} (6 lb/year)	—
Beryllium	Be	8.56×10^{-7}	1.09×10^{-8}	1.09×10^{-7}	3.13×10^{-7}	2.5×10^{-6}	1.09×10^{-5}	1.2×10^{-3} (11 lb/year)	0.0004
Cadmium	Cd	9.35×10^{-7}	1.19×10^{-8}	1.19×10^{-7}	3.42×10^{-7}	2.7×10^{-6}	1.19×10^{-5}	1.6×10^{-3} (14 lb/year)	—
Chromium	Cr	$<9.0 \times 10^{-8}$	$<1.1 \times 10^{-9}$	$<1.1 \times 10^{-8}$	$<3.24 \times 10^{-8}$	$<2.6 \times 10^{-7}$	$<1.13 \times 10^{-6}$	0.11	—
Cobalt	Co	$<9.0 \times 10^{-8}$	$<1.1 \times 10^{-9}$	$<1.1 \times 10^{-8}$	$<3.24 \times 10^{-8}$	$<2.6 \times 10^{-7}$	$<1.13 \times 10^{-6}$	0.01	—
Manganese	Mn	$<9.0 \times 10^{-8}$	$<1.1 \times 10^{-9}$	$<1.1 \times 10^{-8}$	$<3.24 \times 10^{-8}$	$<8.0 \times 10^{-4}$	$<1.13 \times 10^{-6}$	0.25[h]	—
Mercury	Hg	1.7×10^{-5}	9×10^{-5}	1×10^{-5}	1.01×10^{-4}	3.19×10^{-3}	3.52×10^{-3}	0.25[i]	0.1
Nickel	Ni	$<9.0 \times 10^{-8}$	$<1.1 \times 10^{-9}$	$<1.1 \times 10^{-8}$	$<3.24 \times 10^{-8}$	$<1.02 \times 10^{-6}$	$<1.13 \times 10^{-6}$	0.025[j]	—

Table 4.5.3-2
Estimated Regulatory Air Pollutant Emission Rates and Mean Annual Total Masses (Continued)

Pollutant	Chemical Symbol or Abbreviation	Source Full Emission Rate (grams/sec)[a]			PROJECT EMISSIONS			Significant Emission Rates (SER) for Oregon[c]	Significant Emission Rates for Criteria Pollutants
		Wellhead[b] Silencer	Sulferox	Cooling Tower	Average Annual Emission Rate (grams/sec)	Average Annual Emission Rate (lb/hr)	Average Annual Emission Rate (tons/year)	(lb/hr)	(tons/year)[m]
Selenium	Se	1.3×10^{-6}	1.7×10^{-8}	1.7×10^{-7}	4.80×10^{-7}	1.52×10^{-5}	1.67×10^{-5}	0.05	—
Radon-222	^{222}Rn (Curies)	2.7×10^{-10}Ci	1.4×10^{-9}Ci	1.6×10^{-10}Ci	1.58×10^{-9}Ci	1.1×10^{-2}[g]	—	No SER	—
Radon-222	^{222}Rn (g/sec)	1.8×10^{-15}	9.1×10^{-15}	1.0×10^{-15}	1.03×10^{-14}	7.4×10^{-14}	3.57×10^{-13}	No SER	—
Boron	B	1.4×10^{-4}	1.9×10^{-6}	1.9×10^{-5}	5.25×10^{-5}	4.1 x 10 [illegible]	1.82×10^{-3}	2.5[k]	—
Ammonia	NH_3	2.71×10^{-3}	1.4×10^{-2}	1.6×10^{-3}	0.0158	0.12	0.55	3.9	—
Volatile Organic Compounds	VOC	4.44×10^{-7}	2.46×10^{-6}	2.67×10^{-7}	2.76×10^{-6}	2.2×10^{-5}	9.58×10^{-5}	No SER	40
Total Suspended Particles	TSP[d]	0.0390	0.0005	0.0050	0.0143	0.11	0.50	No SER	25

[a]The emission rates from the plant silencer are eight times those from a wellhead silencer.
[b]During well testing or flow to atmosphere when plan is in start-up, shut-down, or upset mode
[c]Significant Emission Rates for hazardous air pollutants (HAPs) are from the Hazardous Air Pollutant Interim Program (Oregon). SERs for HAPs are for Non-Fugitives in pounds per 8 hours (based on occupational health risk). Values are divided by 8 hours to obtain pounds per hour. Values that are provided in the Oregon Interim Program document in pounds per year were divided by 8760 to obtain pounds per hour.
[d]Assumed all particles are either in the PM_{10} or TSP size categories.
[e]Assumed all H_2S converted to SO_2 at exit from stacks and silencers.
[f]Criteria pollutant. Federal standard = 250 tpy (57 lb/hour) to trigger PSD.
[g]Expressed as the total number of Curies per year.
[h]Mn - fumes.
[i]Hg - inorganic compounds.
[j]Ni - soluble compounds.
[k]B - Boron oxide.
[l]Nitrogen oxides (NO_x)
[m]From OAR 340-28-110

Source: SAIC, 1993. (See Appendix F-6)

Table 4.5.3-3
Highest Impacts of Emissions of Regulated Pollutants at Seven Receptors

Pollutant	Highest Concentration During Upset Conditions ($\mu g/m^3$)							
	Nearest NNVM Boundary	Paulina Lake Lodge	Camp 1 (North Cove)	Camp 2 (Warm Springs)	Camp 4 (Houses)	Bald Eagle Management Area	Nearest Class 1 Boundary	PSD Increment or AAL
PM_{10}	6.2	2.5	2.5	1.7	1.6	0.17	0.03	150 $\mu g/m^3$ 24-hour[a] 50 $\mu g/m^3$ annual[a]
Sulfur dioxide	130	42	51	36	27	2.4	0.60	1300 $\mu g/m^3$ 3-hour max. 260 $\mu g/m^3$ 24-hour max. 50 $\mu g/m^3$ annual arithmetic mean (Oregon standards)
Lead	1.5×10^{-4}	6.0×10^{-5}	5.9×10^{-5}	4.0×10^{-5}	3.9×10^{-5}	4.1×10^{-6}	7.2×10^{-7}	1.5 $\mu g/m^3$ calendar quarter
Antimony	2.4×10^{-4}	9.7×10^{-5}	9.7×10^{-5}	6.5×10^{-5}	6.4×10^{-5}	6.6×10^{-6}	1.2×10^{-6}	1.7 $\mu g/m^3$ AAL[b]
Arsenic	1.1×10^{-4}	4.6×10^{-5}	4.5×10^{-5}	3.1×10^{-5}	3.0×10^{-5}	3.1×10^{-6}	5.5×10^{-7}	0.7 $\mu g/m^3$ AAL[b]
Beryllium	1.4×10^{-4}	5.5×10^{-5}	5.4×10^{-5}	3.7×10^{-5}	3.6×10^{-5}	3.7×10^{-6}	6.6×10^{-7}	0.007 $\mu g/m^3$ AAL[b]
Cadmium	1.5×10^{-4}	6.0×10^{-5}	5.9×10^{-5}	4.0×10^{-5}	3.9×10^{-5}	4.1×10^{-6}	7.2×10^{-7}	0.033 $\mu g/m^3$ AAL[b]
Chromium	1.4×10^{-5}	5.8×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	3.8×10^{-6}	3.9×10^{-7}	6.9×10^{-8}	1.7 $\mu g/m^3$ AAL[b]
Cobalt	1.4×10^{-5}	5.8×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	3.8×10^{-6}	3.9×10^{-7}	6.9×10^{-8}	0.17 $\mu g/m^3$ AAL[b]
Manganese	1.4×10^{-5}	5.8×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	3.8×10^{-6}	3.9×10^{-7}	6.9×10^{-8}	17 $\mu g/m^3$ AAL[b]
Mercury	2.7×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	7.7×10^{-4}	7.1×10^{-4}	7.4×10^{-5}	1.3×10^{-5}	0.17 $\mu g/m^3$ AAL[b]
Nickel	1.4×10^{-5}	5.8×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	3.8×10^{-6}	3.9×10^{-7}	7.0×10^{-8}	3.3 $\mu g/m^3$ AAL[b]
Selenium	2.1×10^{-4}	8.3×10^{-5}	8.3×10^{-5}	5.6×10^{-5}	5.5×10^{-5}	5.7×10^{-6}	1.0×10^{-6}	4 $\mu g/m^3$ AAL[b]
Boron	0.02	9.0×10^{-3}	8.9×10^{-3}	6.0×10^{-3}	5.9×10^{-3}	6.1×10^{-4}	1.1×10^{-4}	33 $\mu g/m^3$ AAL[b]
Ammonia	0.43	0.17	0.17	0.12	0.11	0.01	0	90 $\mu g/m^3$ AAL[b] (2154 $\mu g/m^3$)[d]
Volatile Organic Compound	7×10^{-5}	2.8×10^{-5}	2.8×10^{-5}	2.0×10^{-5}	1.8×10^{-5}	1.6×10^{-6}	0	NA
Total Suspended Particulate	6.2	2.50	2.48	1.68	1.64	0.17	.03	150 $\mu g/m^3$ 24-hour 60 $\mu g/m^3$ annual geometric mean (Oregon standard)
Silica (amorphous)	1.02	0.41	0.41	0.28	0.27	0.03	4.9×10^{-3}	
Radon[c]	2.8×10^{-13}	1.1×10^{-13}	1.1×10^{-13}	7.8×10^{-14}	7.2×10^{-14}	6.5×10^{-15}	0	4pCi/l or 2.6×10^{-8} $\mu g/m^3$

[a]Federal standard for PSD increment.
[b]Acceptable Ambient Level (AAL) determined from occupational Threshold Limit Values (TLV) per Oregon's Hazardous Air Pollutant Interim Program (Dec 1991).
[c]Federal indoor standard; outdoor standards do not exist.
[d]Alaska 1-hour standard.

In general, the amount of steam vented to the atmosphere and the duration of venting from well field emissions would be minimized to prevent waste of the resource when the power plant was not operating. However, well field emissions would not be treated unless a well had unusually high levels of H_2S. This is not expected, based on what is known of the site geology at Newberry. Well testing emissions are not expected to exceed ambient air quality standards. H_2S would be emitted and the odor could be detectable under certain atmospheric conditions. Monitoring is therefore proposed. If significant air quality problems are identified, the agencies would require mitigation.

Available treatment technology for wellhead venting of H_2S consists of injecting a peroxide or other similar chemical solution into the venting well to react with H_2S. The effectiveness of this form of emission control is low and results in contaminated liquids. This technique has not been effectively used at Coso, California, on a two-phase (both steam and water) flow from wells and requires the transport of hazardous materials. In addition, this practice increases scaling and corrosion problems within the injection well and raises concerns over injecting treated waste. Other emission control approaches would be to construct a separate condenser/cooling tower at each well head. A preferable op':on would be to limit the number of wells vented at one time

Compliance with PSD Visibility Criteria. Although PSD permitting is not anticipated to be required for this project because the annual emissions rates are below applicable levels, potential visibility impacts at the nearest Class 1 area (Three Sisters Wilderness Area) were assessed at U.S. Forest Service request. A visibility screening model (VISCREEN) was performed for the proposed project emissions to assess impacts at the Three Sisters Wilderness Area. The VISCREEN model is designed to predict whether effects of emissions would be perceived by an observer stationed at the nearest point on the boundary of a Class 1 area during a worst-case meteorological dispersion condition. Actual meteorological data collected at the proposed power plant site were used.

Emissions considered in the VISCREEN model were particulates, nitrogen oxides (NO_x), and sulfate (SO_4^{2-}). Particulate values were calculated from the total dissolved solids contained in the water droplets escaping from the cooling tower, liquid redox vessel, and plant and wellhead silencers. Although sulfate would not be emitted directly in significant amounts, H_2S emissions would convert into sulfur dioxide (SO_2), which in turn would convert slowly to secondary sulfate; the secondary sulfate thus formed must also be considered in terms of visibility degradation. Secondary sulfate emissions rates were calculated with the assumption that a portion of the H_2S emissions would convert immediately to secondary sulfate, with an H_2S half-life of 4 days. For a complete description of the modeling effort, see Appendix F-3.

The results of the study indicate that the plume would not have a perceivable effect on views inside the Wilderness Area by an observer at the closest point along the Three Sisters Wilderness Area boundary. Scenario 4 (plant upset condition with unabated emissions during worst-case dispersion conditions) would, however, cause visibility impact outside the Wilderness Area. From the Wilderness Area, a visibility impact may occur from the power plant out to an approximate distance of 31 km (19 miles). However, the probability of an upset condition (Scenario 4) occurring is estimated to be approximately 24 events in one year based on actual observation at similar geothermal plants. The probability of a 1-hr emission (assumed to cause a visibility impact) at each plant upset event is (24 x 1 hrs) ÷ (365 days x 24 hrs) x 100 percent = 0.27 percent. The probability of occurrence of the worst-case dispersion condition is 1 percent. Therefore, the probability of the 1-hour upset occurring at the same time as the worst-case dispersion condition (thus resulting in a visibility impact from the Wilderness Area looking toward Newberry) is the product of the two probabilities: 0.27 percent x 1 percent = 0.003 percent, which is extremely low. This equates to a visibility impact of less than 1 hour per year.

Deposition. Impacts of deposition of material emitted from the proposed project on the nearby Paulina Lake and East Lake watersheds (not including Paulina Creek) and on nearby vegetation were quantified using the computer models. A copy of the original reports are contained in

Appendices F-5, F-7,and L. Effects of the deposition impacts are discussed in Sections 4.3, Water Resources,4.12, Wildlife, and 4.11, Vegetation.

Impacts to Vegetation. Potential impacts of gaseous air emissions on vegetation near the plant were also quantified using computer models. Average annual concentrations of H_2S, boron, arsenic, and mercury were determined for eight sensitive receptors. A detailed description of the expected emissions, the locations of the sensitive receptors modeled, and the results are found in Appendix F-7. Effects of these concentrations on the vegetation is discussed in Section 4.11, Vegetation.

4.5.3.3. Global Warming

This project would release carbon dioxide (CO_2), a "greenhouse gas", that is a naturally-occurring constituent of geothermal fluids.

As noted in Section 3.5, many scientists and public agencies believe that emissions of CO_2 and other greenhouse gases are leading to a global warming effect. Among power production technologies, geothermal energy systems have very low emissions of CO_2 compared to emissions from fossil fuel combustion. The CO_2 released by geothermal facilities comes from naturally-occurring subterranean sources and is not actually produced during geothermal energy conversion or utilization processes.

Typical CO_2 emissions in pounds per hour per MW for various fuel sources are listed in Table 4.5.3-4. Emission rates at the proposed Newberry geothermal power plant are expected to be about 22 kg (49 pounds) carbon per hour per MW, assuming that 2,700 kg (6,000 pounds) per hour of steam would produce 30 MW, and that most of this would be composed of carbon dioxide. The actual levels are expected to be lower.

Table 4.5.3-4 Comparison of Carbon Emissions from Newberry Project With Fossil-Fueled Operations (Emitted Primarily as CO_2)

Power Plant Fuel Source	Carbon[1] Emissions kilograms per hour per MW (pounds per hour per MW)
NEWBERRY PROJECT[2]	22 (48.9)
FOSSIL-FUEL PLANTS:	
methane	128 (282)
ethane	147 (324)
propane	155 (341)
butane	160 (351)
gasoline	180 (395)
diesel oil	187 (412)
fuel oil #6	190 (418)
bituminous coal	225 (497)
sub-bituminous coal	240 (529)

[1]Studies of the greenhouse effects traditionally express carbon dioxide as pounds of carbon. Multiply by 44/12 to obtain pounds per hour carbon dioxide.

[2]Estimate for Newberry conservatively based upon a rate of 2,700 kg (6,000 pounds) per hour noncondensable gas per 33 MW gross production, assuming that 99 percent of noncondensable gas is carbon dioxide.

Source: Encyclopedia of Physical Science and Technology, Vol. 7

Climatic changes and corresponding global impacts as a result of a significant warming of the earth's atmosphere would be difficult to estimate. It would also be difficult to predict the location and magnitude of the potential effects of greenhouse warming on a particular region. Global climate models currently used are sensitive to large-scale and seasonal changes only (Schneider 1989; Electric Power Research Institute 1988). A possible scenario is that the arid regions of the western U.S. could become hotter and drier if global mean temperature were to increase by 3°C (37°F) (Schneider 1989). Also, possible altered patterns of precipitation and evaporation could affect agriculturally productive areas. Such changes could produce detrimental or beneficial effects depending on geographical location.

It is not possible to accurately evaluate the impact of increased CO_2 emissions from this proposed project, or any individual project, because there is still significant scientific uncertainty concerning global climate change and its relationship to CO_2 emissions. For example, the relative importance of various greenhouse gases is an issue. While CO_2 is the most abundant of the gases of concern, others are more efficient at absorbing heat. Also, deforestation is considered to be a major cause of adverse impacts on global warming trends. Although the areas of uncertainty are being addressed by ongoing studies, the current state of scientific knowledge does not allow the impacts from CO_2 emissions from the proposed project to be understood. However, geothermal energy production has much less of an impact on global warming per megawatt than fossil-fuel burning sources due to smaller CO_2 emissions.

4.5.4. Effects of Alternative A

There are no effects that are unique to Alternative A. Section 2.4.1.7 describes air quality mitigation measures that are included in Alternative A.

4.5.5. Effects of Alternative B

Two alternative power plant sites are considered under Alternative B, which would be expected to have similar meteorological data and modeling results at most receptors because they are only approximately 0.5 km (1,640 ft) and 2.5 km (8,200 ft) in distance and 12 m (39 ft) and 180 m (590 ft) in elevation different, respectively, from the site of the proposed power plant site and of the meteorological station. Impacts of Plant Site 3 at the NNVM boundary may be somewhat greater since it is closer to the boundary. However, impacts at more distant receptors, such as the Class 1 area, would be similar.

Mitigation included as part of Alternative B includes those measures outlined in Section 2.4.2.6, plus:

- Lichen tissue would be monitored and studied and compared to baseline information to test the prediction that air quality impacts to lichen and other vegetation is not anticipated (see Section 4.11, Vegetation).
- Chemical composition of the reservoir steam could be assessed by CEE during exploration and production to determine whether significant levels of mercury may be emitted by the power plant. If significant levels of mercury emissions are found, emission control system(s) will be added to the power plant, such as a charcoal scrubber(s), as required, to reduce emissions and resultant impacts to levels that are acceptable to the agencies.

Baseline and operational monitoring programs would include a continuation of meteorological monitoring at the plant and Paulina Lodge, and H_2S monitoring at both locations.

4.5.6. Additional Mitigation Measures

- An odor complaint program could be implemented by the U.S. Forest Service to log any complaints by visitors or people in the area. Complaints would be evaluated, and if significant, additional mitigation could be required.

- An additional meteorological station, similar to the one presently at the proposed plant site, could be installed to help better define wind patterns and temperature gradients, if necessary.

Since emissions levels are expected to be low and not exceed applicable air quality standards, additional emission control technologies were not proposed and will not be evaluated in this EIS. If initial test results show that emissions of any pollutant are much higher than expected, then the agencies and DEQ could (1) require additional air quality impact modeling using actual well data, (2) require that well production be reduced, (3) limit the number of wells allowed to vent at one time, or (4) require emission controls such as chemical additives, discussed below.

Because no significant air quality impacts have been identified for the proposed project at this level of study (which includes control systems for H_2S, mercury, and fugitive dust emissions in the design), no mitigation has been proposed beyond that built into the project. However, in order to assess whether the project impacts are significant, the following H_2S and meteorological monitoring program is proposed during development and operation:

- Weather data at the existing meteorological station would continue to be monitored to better define and predict weather and wind patterns and their effects.

- H_2S concentrations would be monitored near the plant site in a manner compatible with other monitoring systems.

- Plant operations would be logged to document actual frequency and duration of upset conditions. This information would be used in conjunction with monitoring of meteorology and H_2S concentrations to evaluate the effectiveness of H_2S abatement systems. If significant impacts are measured, additional mitigation will be required that is acceptable to the agencies.

4.5.6. Effects of Alternative C

Under the no-action Alternative C, the effects associated with construction and operation of the proposed project would not occur. However, design modifications to the existing proposals could be considered, which might lead to another proposal for geothermal development at Newberry under different construction and operation scenarios.

4.6. VISUAL RESOURCES

4.6.1. Impact Overview

Impacts to visual resources through the exploratory phase would be primarily oriented toward dust resulting from road and pad clearing and the steam plume resulting from venting. The steam plume would generate a greater visibility, particularly during cooler seasons. Tops of drill rigs may be visible from nearby viewing points. Visual impacts associated with the development and utilization phases of the project would be very similar. Most of the visual changes would result from the clearing of vegetation and trees required for placement of well pad, power plant, access road, and transmission line facilities during the development phase and would continue through utilization. In addition, the steam plume would draw visual attention from viewing locations, especially during cooler seasons. The decommissioning phase would result in less visual change similar to the existing condition. The absence of the steam plume would create less visual variety.

4.6.2. Method of Analysis

The approach used to assess impacts to visual resources for the proposed project was based on U.S. Forest Service guidelines for identifying significant visual contrast. Certain visual contrast effects could likely be long-term (normally defined as greater than 5 years) because most visual change would last for the life of the proposed project. Exploration, development, and utilization activities typically result in visual contrast affecting:

- The quality of any aesthetic resources
- Scenic resources having rare or unique value
- The view from or the visual setting of any designated or planned park, wilderness, or natural area, or of other visually sensitive land use
- The view from or the visual setting of any travel route
- The view from or the visual setting of any established, designated, or planned recreation, education, preservation, or scientific facility, use area activity, and view point or vista

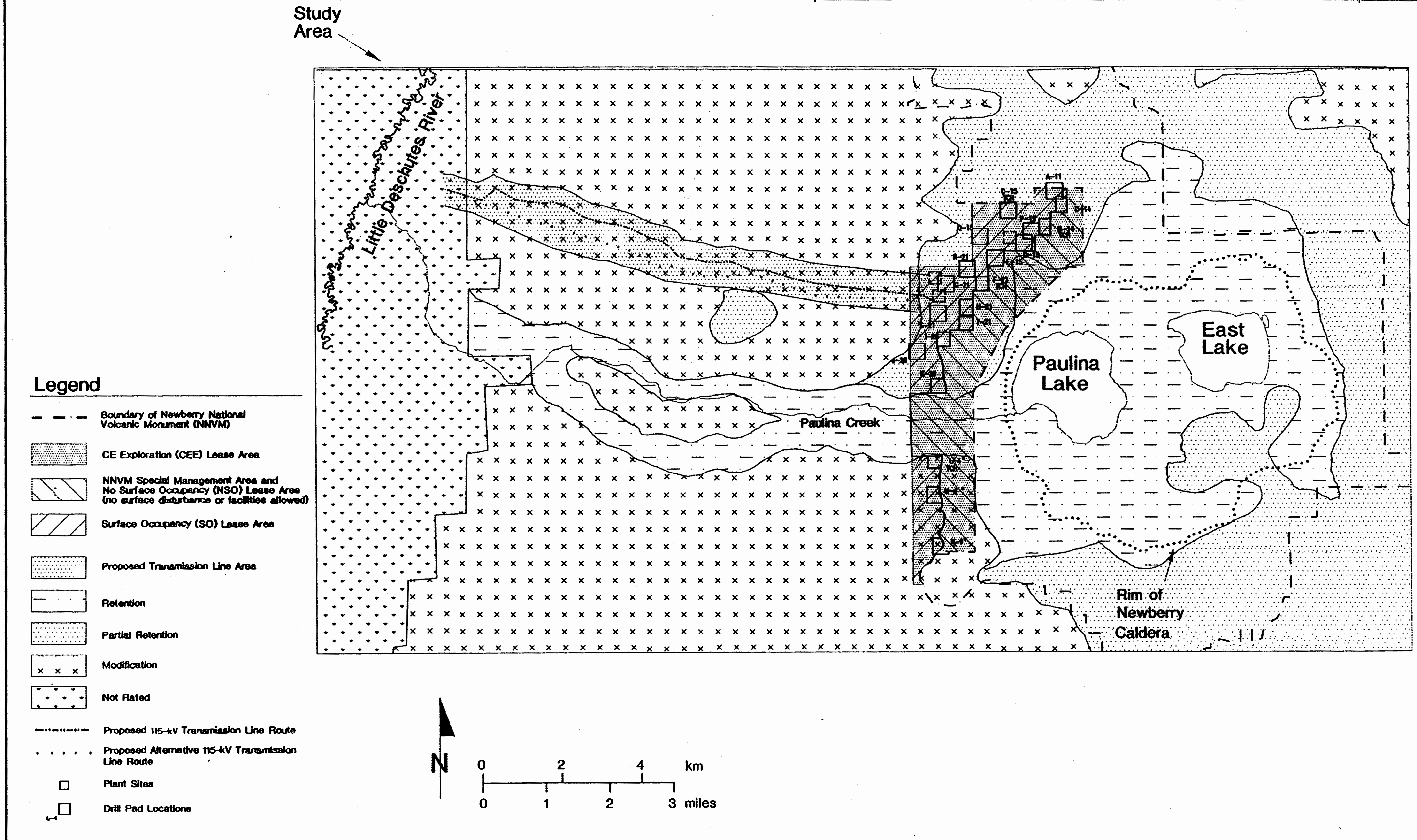
Quality of the visual environment is based on Visual Quality Objectives (VQO) levels of the synthesis of scenic quality and visual sensitivity (Figure 4.6-1). The amount of contrast between the proposed action and the existing landscape character was assessed by separating the landscape into its major features (landforms, vegetation, and structures), and then predicting the magnitude of change when contrasting each of the basic visual elements (form, line, color, and texture) to each of the features. The assessment of visual resources was based upon the net visual change or contrast brought about by the proposed project, facilities, and activities. Areas of sensitive visual resources identified during the baseline investigation were examined, and VAC (visual absorption capability) criteria and an EVC (existing visual condition) map were prepared (Figure 4.6-2).

Other criteria used to rate the level of visual change were scale and spatial dominance. The scale of the project modifications were compared to the scale of the entire landscape setting and placement in the viewshed. Spatial dominance was analyzed based upon the complexity of landscape composition, elevations, and position of the project to the Key Observation Points (KOPs), and landscape background as seen from structures and facilities. The analysis of visual change of features (e.g., landforms and vegetation) to landscape elements (e.g., form, line, texture, and color) was recorded and compared to the threshold defined by the VQO level to determine the level of the impact.

The type of actual physical contrast for the project alternatives was examined by evaluating the following criteria: landforms, soil color and erosion potential, vegetative patterns and diversity, and structure compatibility. Several variables were considered in establishing overall visibility levels: view orientation, lighting conditions, seasonal effects, view distance, duration of view, visibility, viewer numbers, and use association.

The assessment was based on the effects of visual contrast from identified KOPs. The selection of 20 key viewing or observation points (Figure 4.6-3) was based upon the representative or typical condition of the viewers potentially affected by the project alternatives. Of the viewpoints initially studied, three were selected as the most representative viewpoints of the project area for travellers or recreationists. These include two locations in the NNVM (Paulina Peak and Lava Butte), and one location along U.S. Highway 97. A series of photographic simulations (Figures 4.6-5 to 4.6-12) were compiled for the Alternative A plant site and associated well pads and steam plume. These simulations provide a general image of what the project area would look like with and without the facilities in place and operating.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Visual Quality Objectives in the Project Area Showing Project Features	Figure 4.6 - 1



The photo simulations are based on plume heights, lengths, and diameters predicted by a computer model (Argonne National Laboratory 1984). The model accounts for site-specific meteorological, terrain, and other conditions and for cooling tower configuration. More information on the plume prediction model can be found in Appendix F. With the aid of computer imaging, the predicted steam plume was imposed on actual photos of the proposed site from different viewpoints. A discussion of the visual information from the viewpoints is provided below.

4.6.3. Effects Common to Alternatives A and B

Issues identified during scoping included the level of visual contrast, the type and extent of actual physical contrast or aesthetic degradation, the concern of night lighting from various viewer locations, and the level of visibility or viewshed disturbance caused by site location, structures and activities for the proposed project.

Except for the steam plume, most project facilities and activities of Alternatives A and B would not be visible from most visual receptors or sensitive visual resources. Twenty viewing points or key observation points were identified and analyzed for the lease area, plant sites, and the transmission line area (Tables 4.6.-1, 4.6-2, and 4.6-3). Most of the project facilities and activities would not be visible from the twenty viewing points analyzed. This is primarily due to the size of the project relative to the surrounding visual absorption capability. A portion of the facilities and activities would be visible from Paulina Peak and the Rim Trail within the NNVM. Western segments of the CEE proposed transmission line area are generally located in a moderate VAC with some key observation points (U.S. Highway 97, U.S. Forest Service Road 9735, and U.S. Forest Service Road 9736) potentially viewing a portion of these segments.

Two key observation points (Paulina Peak and the Rim Trail) within NNVM would receive long-term indirect effects brought about by the project. During the exploratory phase, summer dust created by construction of access roads and well pads may draw some visual attention. Well pads located south of Paulina Creek including L-4, M-4, and N-9 would be partially visible from Paulina Creek Road (Highway 21). These pads would be within close visual range of the road and viewed from the road's high viewing position. However, each well pad would be located in previously disturbed clearcut landscapes. In addition to dust, occasional vent plume visibility, particularly during winter, may draw visual interest from Paulina Peak KOP during exploration and development phases. Also, the upper portion of construction drill rigs may be visible from well pad sites located near Paulina Peak during exploration and development phases. During the development phase, some larger construction equipment at the plant site may draw some visual attention from the Rim Trail and Paulina Peak KOPs. Construction of the transmission line including right-of-way clearing would draw visual attention including segments seen from Roads 9735 and 9736, and U.S. Highway 97.

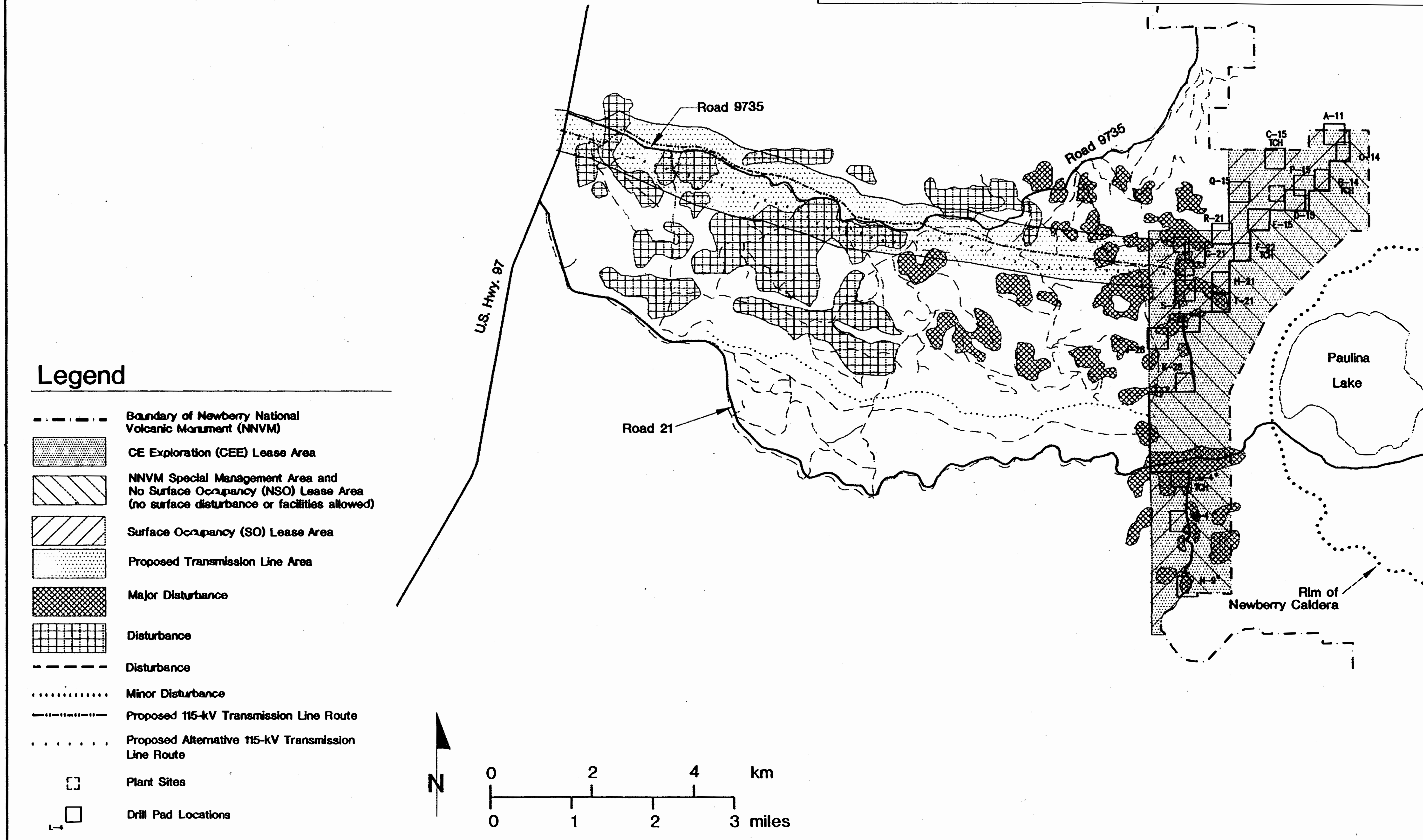
For the utilization phase, the pad locations would not be very visible, with only a portion of small clearings seen from Paulina Peak. The venting activities resulting in a steam plume would be seen from Paulina Peak and the Rim Trail. The plant site facilities would not be visible. However, the plant site summer steam plume would draw visual attention from Paulina Peak. The plume would attract occasional visual interest from hikers travelling in a counterclockwise direction from northeast segments of the Rim Trail. Viewers at more distant KOPs including Lava Butte, U.S. Highway 97, and Mount Bachelor would see the plume, but the plume would be visually subordinate to the surrounding landscape and viewers would not be visually drawn to it. The transmission line area would be visible in less opaque landscapes (e.g., clear cut areas) along segments of travel routes of Roads 9735 and 9736. This area may draw occasional visual attention. In the event that a forest fire or a U.S. Forest Service thinning project occurred, the VAC would be significantly lowered resulting in a higher visibility of project facilities and activities. Project facilities may be visible from the Rim Trail, Paulina Peak, and Paulina Peak Road if these events occurred.

NEWBERRY GEOTHERMAL PILOT PROJECT

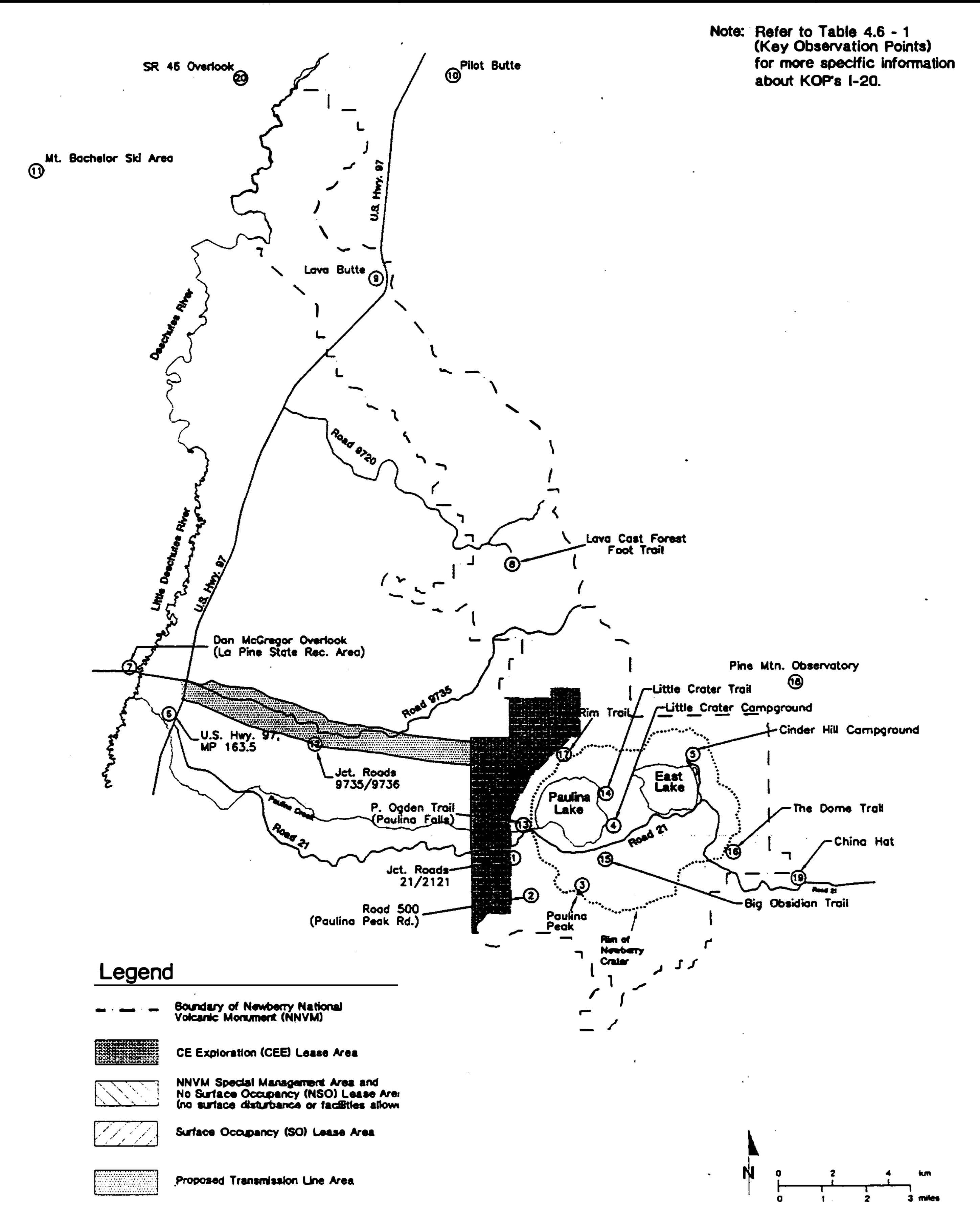
Deschutes National Forest, Oregon

Existing Visual Condition Showing Project Features

Figure 4.6 - 2



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Key Observation Points	Figure 4.6-3



The structures and facilities will be in compliance with Forest Plan visual quality objectives for the management areas. However, the Forest Plan does not specifically address visual aspects of the steam plume. Based on the analysis for this EIS, a non-significant Forest Plan amendment will be included in the Record of Decision to account for the fact that the steam plume may exceed the classification of partial retention, particularly when viewed from Paulina Peak.

During decommissioning, the activities associated with this phase are not likely to cause effects drawing visual concern. The steam plume would be eliminated creating some change in visual diversity as viewed from the above KOPs. The transmission line removal would enhance the scenic quality from travel routes including Highway 97 and Roads 9735 and 9736. The feathered right of way, pad sites, and plant site would gradually fill in with vegetation further reducing the line, texture, and color contrast. Because each major project facility presents distinct visual impacts, discussion of impacts is presented below by facility.

4.6.3.1. Plant Site

Except for the steam plume, most project facilities would not be visible because of moderate to high VAC consisting of surrounding forest crown height and density. The tallest structure, the turbine and generator shed, would be 22.9 meters (75 feet) high, which is about the same height as the forest. The steam plume, which would be generated from the cooling towers at the proposed plant site, would be visible from only a few KOPs in the summer and most KOPs in winter. This would primarily be attributed to significant differences in evaporation rates. The size of the plume during summer would extend from the 16-meter (50 feet) cooling tower, an additional 35 meters (109 feet) in height and 120 meters (372 feet) in length. The radius would average 18 meters (56 feet). For winter, the average height would extend to 80 meters (248 feet) above the cooling tower, the length would be 300 meters (930 feet), and the radius 45 meters (140 feet). Visibility of the plume would not only be attributed to its size, but also its density. At times the plume would be less dense (opaque) and less visible.

The effects of night lighting and night glow condition would not draw strong visual attention from recreation areas and travel routes in the study area. Except for Paulina Peak and Paulina Peak Road, there would be no direct illumination from the plant site or well pads to camp sites, lodges or other sensitive-visual receptors within NNVM or other viewing locations including Mount Bachelor and Three Sisters Wilderness. Adjacent tree heights and density and intervening caldera rim topography will result in a high visual absorption capability which would screen out direct illumination. However, a dim night glow of the plant site may be visible from these locations.

4.6.3.2. Well Pads and Gathering System

Except from Paulina Peak and Paulina Peak Road, most cleared well pad areas north of Paulina Creek would not be visible. For both Paulina Peak and Paulina Peak Road KOPs, a slight color, line, and texture contrast of the forest canopy would be caused by well pad tree clearing activities. (Clearing activities would only take place in a portion of the project, because a number of the well pad locations are contained within already clearcut areas.) The scale and visual contrast of these well pad facilities and activities would remain subordinate to the existing landscape and would not draw visual attention. In addition, no well pad facilities and activities or connecting lines or access roads would be visible from the KOPs.

During development, and occasionally during facility utilization, well venting, resulting in a steam plume, would occur for certain well locations throughout the project area. No more than two wells would be vented at one time. During the exploratory and development phases, this would result in up to a 90-day period of venting during testing. During utilization, this activity may occur one to two times a year for a shorter duration. The height of the steam plume would range from 12 meters (40 feet) in summer to 87 meters (285 feet) in winter above the 15-meter (50-foot) cooling tower.

In order to reduce visual impacts, project design and operation would:

- Site facilities to maximize topographic shielding of these facilities.

- Keep well testing (which results in steam plumes) to the minimum and within the time necessary to gather required data.

- Locate well pads and plant facilities in already clearcut areas, where possible.

- Take into consideration the coloring of facilities to blend with the landscape (detailed suggestions for this action are provided below).

4.6.3.3. Transmission Line

Transmission line structures and the cleared right-of-way would create low line, texture, and color contrast in summer and moderate line, texture and color contrast to vegetation during winter. The scale of the structure size would not dominate the cleared right of way space and would not dominate visual interest. At the junction of Roads 9735 and 9736, KOP segments of the area would draw more visual attention, particularly in open clearcut areas where the VAC is lower. The western segment of the transmission line area would be visible briefly to travellers along Highway 97. Due to a moderate-to-high VAC resulting from tree cover, perpendicular crossing, and brief viewing duration, the area would not draw visual attention. The transmission line area would not be visible from the communities of Sun River or LaPine.

4.6.3.4. Strategic Location

For reducing impacts to visual resources, there are three types of mitigation techniques: (1) strategic location, (2) minimization of disturbance, and (3) repetition of the basic landscape elements (form, line, color, texture). Based on these techniques, mitigation recommendations have been identified for project activities and described to effectively reduce visual contrast for the project facilities and activities.

This mitigation technique has been considered in the action alternatives to effectively reduce visibility of the 115-kV line by locating facilities in previously disturbed landscapes (e.g., clearcut areas). New trees would be strategically grouped and located to help break up or screen out visibility of the plant site.

4.6.3.5. Minimization of Disturbance

During construction, clearing of land for project facilities or structures would use curvilinear boundaries where practicable instead of straight lines. Grading would be done in a manner which would minimize erosion and conform to the natural topography. The clearing of trees and vegetation for the project facilities would be limited to the minimum area required. To the extent possible, all foliage, particularly the coniferous trees adjacent to the project area, would remain undisturbed to provide maximum screening of the installation of a given project facility.

Brush or small trees cleared and not otherwise disposed of would be spread to provide cover habitat for small mammals, reptiles and birds. Woody materials would be randomly placed in areas to conform to adjacent vegetation patterns. All timber and other vegetation material without value would be mechanically chipped and spread to aid seedling establishment and soil stabilization. Large size down woody material would be left in the transmission line area. Within the feathered vegetation zone of the transmission line area, large trees would be topped instead of felled if they posed a danger to electrical lines, so they also may continue to provide foraging and nesting habitat.

Soil which had been excavated during construction and not used would be evenly backfilled into the cleared area. The soil would be graded to conform with the terrain and the adjacent landscape.

4.6.3.6. Repetition of Basic Landscape Elements

The use of the basic landscape elements for facility planning and design would be considered. This measure would be one of the most effective techniques to reduce visual impact and improve aesthetics of the project. Simplified structures and coverings would be used to enhance the overall appearance of the project area facilities. Except for the 22.9-m (75-ft) turbine building and stack, most structures would be less than 9.1 to 12.2 meters (30 to 40 feet) high and the minimum size to satisfy present and future functional requirements. Cooling towers would be designed to minimize the size of the steam plume. Creative landscaping would be applied in visible or sensitive areas to enhance the appearance of project facility installation. Selection of trees and other plants for landscaping would be based on their ability to blend with existing vegetation. Consideration would be given to:

- Mulching cleared cut and fill areas
- Controlling planting times
- Furrowing slopes
- Planting patterns on cut/fill slopes
- Choosing native plant species
- Stockpiling and reusing topsoil
- Fertilizing, mulching, and watering vegetation
- Adding mulch, hydromulch, or topsoil
- Shaping cuts and fills to appear as natural forms
- Cutting rock areas so forms are irregular
- Designing to take advantage of natural screens (i.e., vegetation, landforms)
- Grass seedings of cuts and fills

Exterior night lighting for project facilities would be adequate for work and for protection of project facilities from sabotage and malicious mischief and would minimize reflective glow to the adjacent Newberry National Volcanic Monument. Night lighting would be selected and designed to reduce potential visual impacts due to disturbance of the night sky.

Consideration would be given to coloring facilities' structures (e.g., buildings, pipelines, transmission poles) to blend with the landscape. This is particularly significant in or near areas of high scenic value (Robinette 1973).

- The colors would be uniform and noncontrasting to blend with the immediate natural environment. The warmest color tones would be considered for natural settings.
- Exposed concrete color would match surrounding soil color.
- Unless specified otherwise, colors would be selected on the basis of their ability to blend with the land and not the sky.

- Project facilities would be painted a shade darker than the adjacent landscape to compensate for the effects of shade and shadow.
- Paint finishes with low levels of reflectivity (i.e., flat or semi-gloss) would be used.
- Colors equivalent to the Munsell Soil Color Coding System and displayed on the Standard Environmental Color Chart would be considered for all project facilities.

4.6.4. Effects Specific to Alternative A

With the exception of Paulina Peak (KOP 3, see Table 4.6-1 and Figure 4.6-4), the plant site facilities and activities would not be visible from any other KOP, including those within NNVM. Modeling was performed for certain views from the location of Alternative A Plant Site in order to establish, from which locations and viewpoints the plant site and associated winter steam plume and summer steam plume would be visible. Results of this visibility analysis for Alternative A Plant Site are shown graphically in Figure 4.6-4. All areas shown in black on the figure indicate those areas from which the proposed plant site alternative would be visible. From Paulina Peak, that visible portion of the plant would mainly consist of roof tops and upper portions of taller facilities. No smaller buildings or structures and no ground activities would be visible from this KOP. The VAC components of vegetation type, height, density and topography would factor into the plant site's low visibility. Viewers at all other KOPs within NNVM would not see the Alternative A plant site. Table 4.6-1 presents visibility results from all 20 KOPs analyzed.

A series of photographic simulations were compiled for the Alternative A plant site and associated well pads and steam plume. These simulations provide a general image of what the project area would look like with and without the facilities in place and operation. Figures 4.6-5 and 4.6-6 show the views from Paulina Peak. The simulated photo displays three plumes (one from the plant site and two from well sites during venting) during summer. In addition, several other well pads which show trees cleared are displayed. Figures 4.6-7 and 4.6-8 show views from Lava Butte during summer viewing conditions, which shows that a small portion of the plant site plume would be seen during summer and that no vented well sites would be visible. Figures 4.6-9 and 4.6-10 are simulations of this alternative from Highway 97 during summer, and Figures 4.6-11 and 4.6-12 show the view during winter viewing conditions. Two photo simulations were prepared to show summer and winter representative viewing conditions. No vent plumes would be visible during summer. The vent plumes could possibly be seen during winter on cold sunlit days; however, our photo was of a hazy over cast condition where the plant site's plume blended very closely to the low cloud ceiling.

Based on results of the visibility modeling and use of photographic simulations, the proposed plant would be visible from a limited number of KOPs. It is anticipated that over the long-term, indirect visual impacts would be brought about by construction and operation of the plant. The effects of the transmission line alternative are similar to the effects described under Section 4.6.3 regarding the transmission line area. All mitigation presented for the action alternatives discussion (4.6.3) would be applied to this alternative.

4.6.5. Effects Specific to Alternative B

The six additional alternative well pads would create low impacts similar to those described for Alternative A. Most of the connecting lines and access roads would not be visible and would create very low impacts to visual resources.

TABLE 4.6-1
Key Observation Points, Alternative A

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 1 in kilometers (miles)	Project Facilities Seen[6]: Alternate A Plant Site 1	14 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 1 Winter Steam Plume[7]	Site 1 Summer Steam Plume[8]
1	U.S. Forest Service 21 & 2121	1844 (6050)	N	D	R/H	N	3.9 (2.4)	N	N	N	N	Y	Y
2	U.S. Forest Service 500 @ Sec 3 & 10 (Paulina Peak Rd)	2258 (7000)	NNW	D	PR/M-H	S	5.8 (3.6)	Y	Y	Y	Y	Y	Y
3	Paulina Peak	2434 (7984)	NW	MIN	PR/M-H	S	6.4 (4.0)	Y	Y	Y	Y	Y	Y
4	Little Crater Campground	1932 (6340)	WNW	MOD	R/H	N	5.6 (3.5)	N	N	N	N	Y	N
5	Cinder Hill Campground	1932 (6340)	W	MOD	R/H	N	8.0 (5.0)	N	N	N	N	Y	N
6	U.S. 97 (MP 163.5)	1283 (4210)	E	D	NR/M-H	I	13.7 (8.5)	N	N	N	Y	Y	Y
7	Don McGregor Overlook (LaPine St. Rec. Area)	1348 (4180)	E	UNN	NR/M-H	I	17.7 (11.0)	N	N	N	Y	Y	N
8	Lava Cast Forest (Foot Trail - Stop 9)	1861 (6105)	S	UNN	R/H	N	9.0 (5.6)	N	N	N	N	Y	N
9	Lava Butte	1529 (5016)	SSE	MOD	R/H	I	21.0 (13.0)	N	N	N	N	Y	N
10	Pilot Butte	1261 (4138)	S	D	NR/H	I	37.0 (23.0)	N	N	N	N	Y*	N
11	Mt. Bachelor Ski Area	2743 (9000)	SE	D	R/H	S	41.8 (26.0)	N	N	N	N	Y*	N
12	U.S. Forest Service 9735 and 9736	1437 (4670)	ESE	D	M/M-H	I	7.2 (4.5)	N	N	N	Y	Y	N

TABLE 4.6-1
Key Observation Points, Alternative A (Continued)

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 1 in kilometers (miles)	Project Facilities Seen[6]: Alternate A Plant Site 1	14 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 1 Winter Steam Plume[7]	Site 1 Summer Steam Plume[8]
13	Peter Skene Ogden Trail (Paulina Creek Falls)	1902 (6240)	NNW	D	R/H	N	3.1 (1.9)	N	N	N	N	Y	N
14	Little Crater Trail	1932 (6340)	WNW	UNN	R/H	N	4.5 (2.8)	N	N	N	N	Y	N
15	Big Obsidian Trail	1902 (6420)	WNW	UNN	R/H	N	6.1 (3.8)	N	N	N	N	Y	N
16	The Dome Trail	2290 (7100)	WNW	UNN	R/H	N	8.8 (5.5)	N	N	N	N	Y	N
17	Rim Trail	2091 (6860)	W	MIN	R/M-H	S	2.5 (1.6)	Y	Y	N	Y	Y	Y
18	Pine Mtn. Observatory	1935 (6349)	WSW	D	PR/H	N	32.2 (20.0)	N	N	N	N	Y*	N
19	China Hat	2003 (6570)	WNW	D	PR/H	N	25.7 (16.0)	N	N	N	N	Y*	N
20	SR 46 (Overlook MP9.5)	1503 (4550)	SE	MIN	NR/H	I	30.6 (19.0)	N	N	N	N	Y*	N

[1]N - North, S - South, E - East, W - West

[2]EVC - Existing Visual Condition, UNN - Unnoticeable, MIN - Minor Disturbances, MOD - Moderately Disturbed, D - Disturbed, MAJ - Major Disturbance

[3]VQO - Visual Quality Objective, P - Preservation, R - Retention, PR - Partial Retention, NR - Not Rated, H - High, M - Moderate, L - Low

[4]VAC - Visual Absorption Capability, H - High, M - Moderate, L - Low

[5]S - Superior, N - Normal, I - Inferior

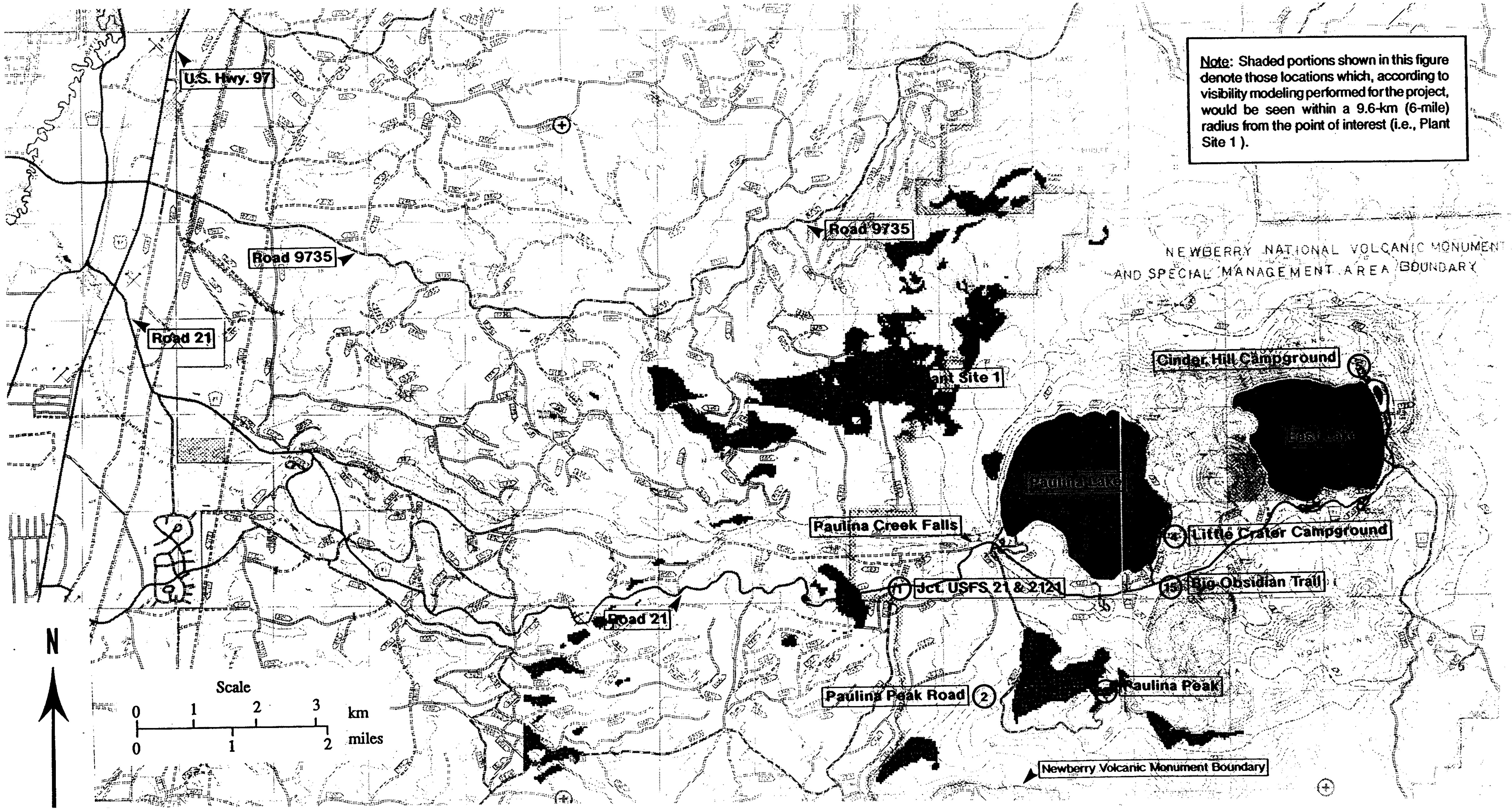
[6]N - Not Visible, Y - Visible

[7]Winter steam plume average height 80 meters (248 ft.) and length 300 meters (930 ft.) plus 15 meters (50 ft.) cooling tower height

[8]Summer steam plume average height 35 meters (109 ft.) and length 120 meters (372 ft.) plus 15 meters (50 ft.) cooling tower height

*Not likely to be obvious to most viewers.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Extent of Visibility Field for Plant Site 1	Figure 4.6-4



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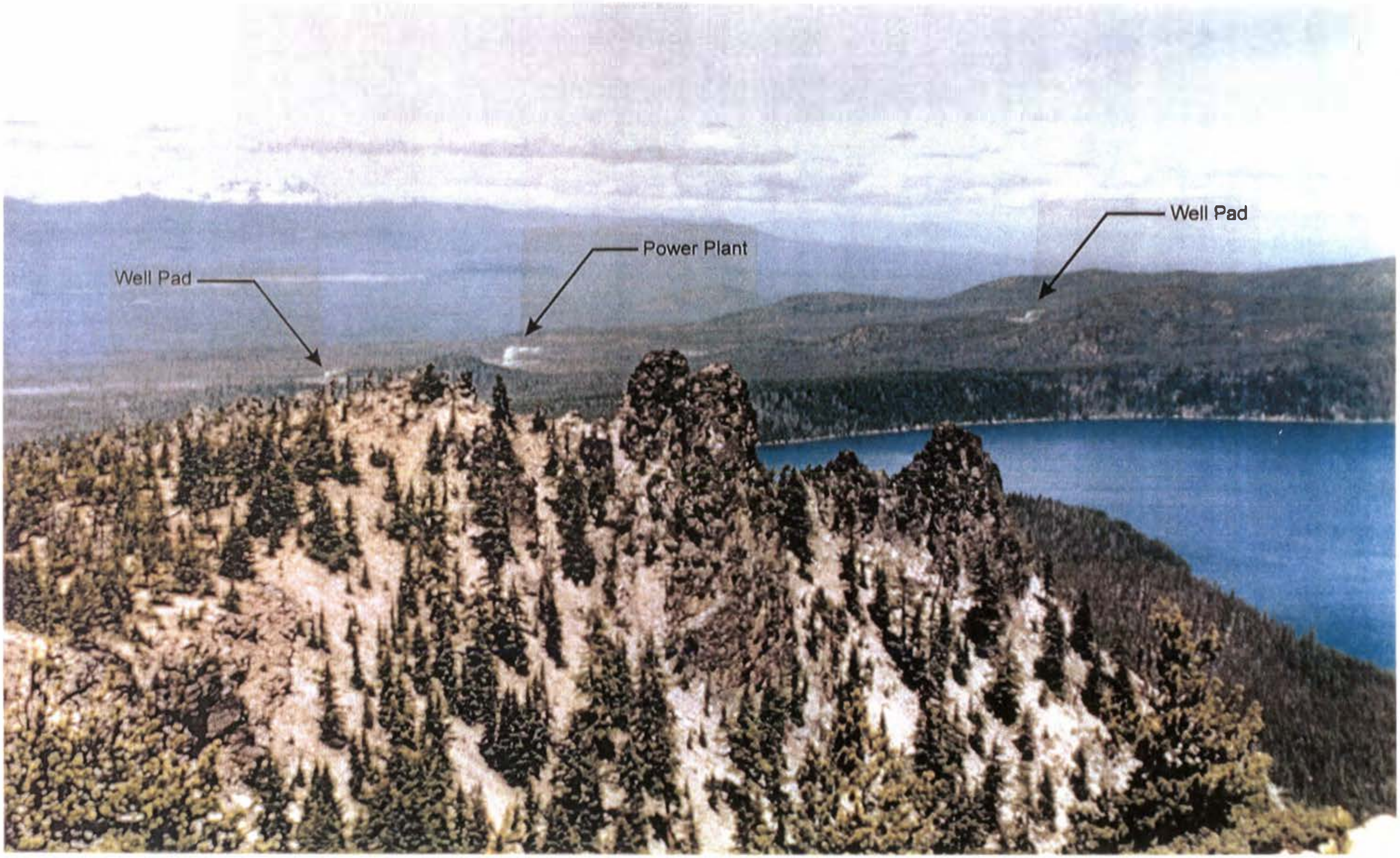
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Existing View from Paulina Peak (During Summer)	Figure 4.6-5

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Simulated View of Proposed Project from Paulina Peak (During Summer)	Figure 4.6-6



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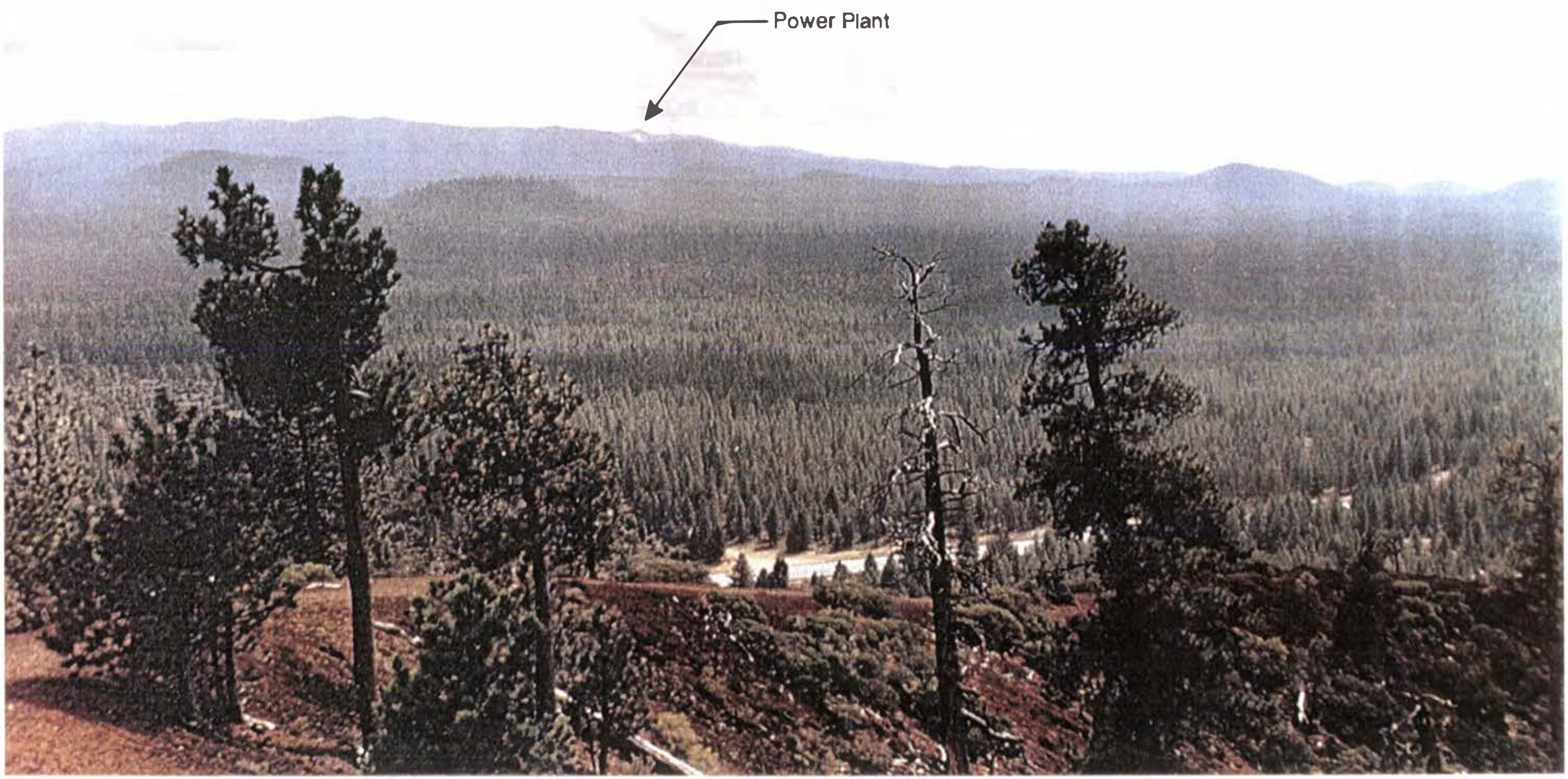
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Existing View from Lava Butte (During Summer)	Figure 4.6-7

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Simulated View of Proposed Project from Lava Butte (During Summer)	Figure 4.6-8



NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Existing View from Highway 97 (During Summer)	Figure 4.6-9

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NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Simulated View of Proposed Project from Highway 97 (During Summer)	Figure 4.6-10

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Existing View from Highway 97 (During Winter)	Figure 4.6-11

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NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Simulated View of Proposed Project from Highway 97 (During Winter)	Figure 4.6-12

Similar effects described for Plant Site 1 would occur for Plant Sites 2 and 3. Plant Site 2 would be slightly more visible than Plant Site 1 from Paulina Peak (KOP 3) due primarily to the lack of visual screening resulting from timber harvesting. However, the Plant Site 2 would be located a distance of 0.8 km (0.5 mile) further away from the KOP partially compensating for the lack of tree screening. Except for Paulina Peak, viewers at all other KOPs within the NNVM would not see the Plant Site 2 facilities or activities (Table 4.6-2 and Figure 4.6-13). None of the viewers at any KOP within or outside NNVM would see the location of Plant Site 3 (Table 4.6-3 and Figure 4.6-14). Figure 4.6-15 is a composite display of the three alternative plant sites. The analysis shows that the location of Plant Site 3 would be the least visible of the alternatives analyzed.

The winter steam plume for all alternative plant sites would be visible from the NNVM KOPs. From Mount Bachelor KOP each plant site alternative winter steam plume would be visually evident but not dominate the landscape. For the summer steam plume Plant Site 3 would be the least visible from KOPs within NNVM of the alternatives analyzed.

Except for a few corridor segments, similar impacts identified for the Alternative A transmission line area would also occur for Alternative B area. Due to its further distance from Road 9735, and the high VAC of forest cover, segments of the Alternative B transmission line would be less visible from this road than the Alternative A transmission line resulting in lower visual effects. At the crossing of Highway 97 effects for each alternative would result in low to moderate long-term direct effects as seen from the travel route.

The mitigation proposed for Alternative A would also be applied to Alternative B. Additionally, the following mitigation would be included:

- Feathering vegetation vertically and horizontally in the transmission line area will be performed to minimize appearances of long straight edges of a cleared swath.

- Where possible, segments of the transmission area would be located in previously disturbed landscapes (e.g., clearcut areas) to reduce visibility of the line.

- Trees would be planted in strategically grouped and selected locations to help break up or screen out visibility of the plant or other facilities.

- During construction of transmission lines and pipelines, land clearing for project facilities or structures would use curvilinear boundaries where practicable instead of straight lines.

- Brush or small trees cleared and not otherwise disposed of would be spread to provide cover habitat for small mammals, reptiles and birds. Woody materials would be randomly placed in areas to conform to adjacent vegetation patterns. All timber and other vegetation material without market value would be mechanically chipped and spread in a manner that would aid seedling establishment and soil stabilization.

- The use of the basic landscape elements for facility planning and design would be considered. This measure would be one of the most effective techniques to reduce visual impact of the project. Simplified structures and coverings would be used to enhance the overall appearance of the project area facilities.

- Creative landscaping would be applied in visible or sensitive areas to enhance the appearance of project facility installation. Selection of trees and other plants for landscaping would be based on their ability to blend with existing vegetation, utilizing native species where possible.

TABLE 4.6-2
Key Observation Points, Alternative B — Site 2

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 2 in kilometers (miles)	Project Facilities Seen[6]: Alternate B Plant Site 2	6 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 2 Winter Steam Plume[7]	Site 2 Summer Steam Plume[8]
1	U.S. Forest Service 21 & 2121	1844 (6050)	N	D	R/H	N	4.6 (2.9)	N	N	N	N	Y	Y
2	U.S. Forest Service 500 @ Sec 3 & 10 (Paulina Peak Rd)	2258 (7000)	NNW	D	PR/M-H	S	6.6 (4.1)	Y	Y	Y	Y	Y	Y
3	Paulina Peak	2434 (7984)	NW	MIN	PR/M-H	S	7.2 (4.5)	Y	Y	Y	Y	Y	Y
4	Little Crater Campground	1932 (6340)	WNW	MOD	R/H	N	5.9 (3.7)	N	N	N	N	Y	N
5	Cinder Hill Campground	1932 (6340)	W	MOD	R/H	N	8.3 (5.2)	N	N	N	N	Y	N
6	U.S. 97 (MP 163.5)	1283 (4210)	E	D	NR/M-H	I	13.3 (8.3)	N	N	N	Y	Y	Y
7	Don McGregor Overlook (LaPine St. Rec. Area)	1348 (4180)	E	UNN	NR/M-H	I	17.3 (10.8)	N	N	N	Y	Y	N
8	Lava Cast Forest (Foot Trail - Stop 9)	1861 (6105)	S	UNN	R/H	N	8.2 (5.1)	N	N	N	N	Y	N
9	Lava Butte	1529 (5016)	SSE	MOD	R/H	I	20.0 (12.5)	N	N	N	N	Y	Y
10	Pilot Butte	1261 (4138)	S	D	NR/H	I	36.0 (22.5)	N	N	N	N	Y*	N
11	Mt. Bachelor Ski Area	2743 (9000)	SE	D	R/H	S	40.8 (25.5)	N	N	N	N	Y*	N
12	U.S. Forest Service 9735 and 9736	1437 (4670)	ESE	D	M/M-H	I	6.7 (4.2)	N	N	N	Y	Y	N

TABLE 4.6-2
Key Observation Points, Alternative B — Site 2 (Continued)

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 2 in kilometers (miles)	Project Facilities Seen[6]: Alternate B Plant Site 2	6 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 2 Winter Steam Plume[7]	Site 2 Summer Steam Plume[8]
13	Peter Skene Ogden Trail (Paulina Creek Falls)	1902 (6240)	NNW	D	R/H	N	3.8 (2.4)	N	N	N	N	Y	N
14	Little Crater Trail	1932 (6340)	WNW	UNN	R/H	N	5.1 (3.2)	N	N	N	N	Y	N
15	Big Obsidian Trail	1902 (6420)	WNW	UNN	R/H	N	7.0 (4.4)	N	N	N	N	Y	N
16	The Dome Trail	2290 (7100)	WNW	UNN	R/H	N	9.4 (5.9)	N	N	N	N	Y	N
17	Rim Trail	2091 (6860)	W	MIN	R/M-H	S	3.0 (1.9)	Y	Y	N	Y	Y	Y
18	Pine Mtn. Observatory	1935 (6349)	WSW	D	PR/H	N	32.5 (20.3)	N	N	N	N	Y*	N
19	China Hat	2003 (6570)	WNW	D	PR/H	N	26.1 (16.3)	N	N	N	N	Y*	N
20	SR 46 (Overlook MP9.5)	1503 (4660)	SE	MIN	NR/H	I	30.1 (18.8)	N	N	N	N	Y*	N

[1] N - North, S - South, E - East, W - West

[2] EVC - Existing Visual Condition, UNN - Unnoticeable, MIN - Minor Disturbances, MOD - Moderately Disturbed, D - Disturbed, MAJ - Major Disturbance

[3] VQO - Visual Quality Objective, P - Preservation, R - Retention, PR - Partial Retention, NR - Not Rated, H - High, M - Moderate, L - Low

[4] VAC - Visual Absorption Capability, H - High, M - Moderate, L - Low

[5] S - Superior, N - Normal, I - Inferior

[6] N - Not Visible, Y - Visible

[7] Winter steam plume average height 80 meters (248 ft.) and length 300 meters (930 ft.) plus 15 meters (50 ft.) cooling tower height

[8] Summer steam plume average height 35 meters (109 ft.) and length 120 meters (372 ft.) plus 15 meters (50 ft.) cooling tower height

*Not likely to be obvious to most viewers.

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NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Extent of Visibility Field for Plant Site 2	Figure 4.6-13

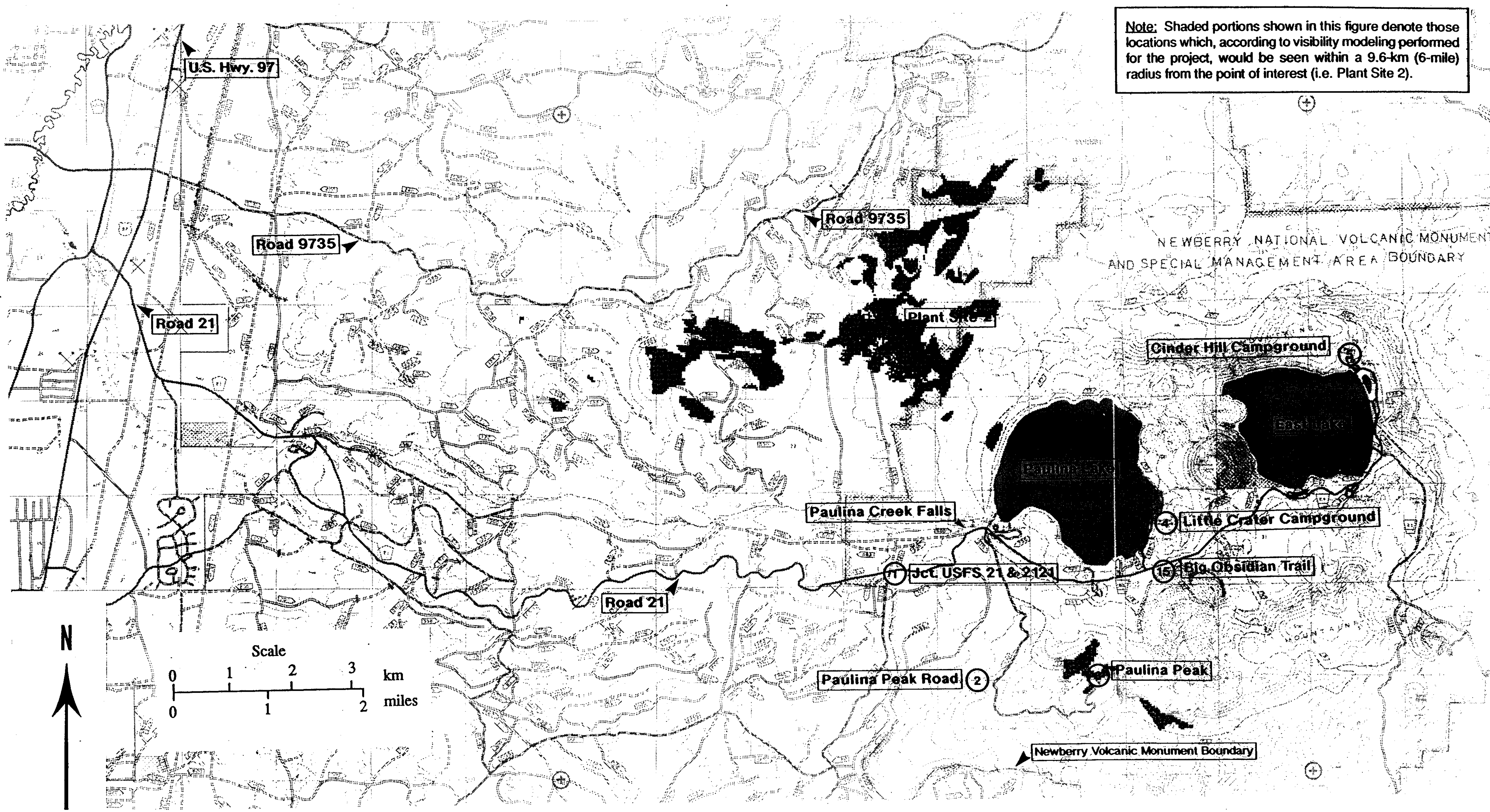

TABLE 4.6-3
Key Observation Points, Alternative B — Site 3

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 3 in kilometers (miles)	Project Facilities Seen[6]					
								Alternate B Plant Site 3	6 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 3 Winter Steam Plume[7]	Site 3 Summer Steam Plume[8]
1	U.S. Forest Service 21 & 2121	1844 (6050)	N/NE	D	R/H	N	6.2 (3.9)	N	N	N	N	Y	Y
2	U.S. Forest Service 500 @ Sec 3 & 10 (Paulina Peak Rd)	2258 (7000)	N	D	PR/M-H	S	7.4 (4.6)	N	Y	N	Y	Y	Y
3	Paulina Peak	2434 (7984)	NNW	MIN	PR/M-H	S	8.0 (5.0)	N	Y	Y	Y	Y	Y
4	Little Crater Campground	1932 (6340)	WNW	MOD	R/H	N	5.6 (3.5)	N	N	N	N	Y	N
5	Cinder Hill Campground	1932 (6340)	W	MOD	R/H	N	8.5 (5.3)	N	N	N	N	Y	N
6	U.S. 97 (MP 163.5)	1283 (4210)	E	D	NR/M-H	I	14.9 (9.3)	N	N	N	Y	Y	Y
7	Don McGregor Overlook (LaPine St. Rec. Area)	1348 (4180)	E	UNN	NR/M-H	I	18.9 (11.8)	N	N	N	Y	Y	Y
8	Lava Cast Forest (Foot Trail - Stop 9)	1861 (6105)	S	UNN	R/H	N	7.5 (4.7)	N	N	N	N	Y	N
9	Lava Butte	1529 (5016)	SSE	MOD	R/H	I	19.4 (12.1)	N	N	N	N	Y	Y
10	Pilot Butte	1261 (4138)	S	D	NR/H	I	35.4 (22.1)	N	N	N	N	Y*	N
11	Mt. Bachelor Ski Area	2743 (9000)	SE	D	R/H	S	42.4 (26.5)	N	N	N	N	Y*	N
12	U.S. Forest Service 9735 and 9736	1437 (4670)	E	D	M/M-H	I	8.6 (5.4)	N	N	N	Y	Y	N

TABLE 4.6-3
Key Observation Points, Alternative B — Site 3 (Continued)

Reference Number for Figure 4.6-3	Viewpoint	Elevation in meters (feet)	View Direction[1] Toward Plant Site	Viewpoint EVC[2]	Viewpoint VQO[3]/VAC[4]	Viewer Position[5]	View Distance Plant Site 3 in kilometers (miles)	Project Facilities Seen[6]					
								Alternate B Plant Site 3	6 New Well Pads	Access Roads	Proposed Trans-mission Line	Site 3 Winter Steam Plume[7]	Site 3 Summer Steam Plume[8]
13	Peter Skene Ogden Trail (Paulina Creek Falls)	1902 (6240)	N	D	R/H	N	4.5 (2.8)	N	N	N	N	Y	N
14	Little Crater Trail	1932 (6340)	WNW	UNN	R/H	N	5.3 (3.3)	N	N	N	N	Y	N
15	Big Obsidian Trail	1902 (6420)	WNW	UNN	R/H	N	6.6 (4.1)	N	N	N	N	Y	N
16	The Dome Trail	2290 (7100)	WNW	UNN	R/H	N	9.3 (5.8)	N	N	N	N	Y	N
17	Rim Trail	2091 (6860)	NW	MIN	R/M-H	S	2.4 (1.5)	N	Y	N	Y	Y	N
18	Pine Mtn. Observatory	1935 (6349)	WSW	D	PR/H	N	30.1 (19.3)	N	N	N	N	Y*	N
19	China Hat	2003 (6570)	WNW	D	PR/H	N	24.5 (15.3)	N	N	N	N	N*	N
20	SR 46 (Overlook MP9.5)	1503 (4660)	SE	MIN	NR/H	I	32.2 (20.0)	N	N	N	N	Y*	N

[1]N - North, S - South, E - East, W - West

[2]EVC - Existing Visual Condition, UNN - Unnoticeable, MIN - Minor Disturbances, MOD - Moderately Disturbed, D - Disturbed, MAJ - Major Disturbance

[3]VQO - Visual Quality Objective, P - Preservation, R - Retention, PR - Partial Retention, NR - Not Rated, H - High, M - Moderate, L - Low

[4]VAC - Visual Absorption Capability, H - High, M - Moderate, L - Low

[5]S - Superior, N - Normal, I - Inferior

[6]N - Not Visible, Y - Visible

[7]Winter steam plume average height 80 meters (248 ft.) and length 300 meters (930 ft.) plus 15 meters (50 ft.) cooling tower height

[8]Summer steam plume average height 35 meters (109 ft.) and length 120 meters (372 ft.) plus 15 meters (50 ft.) cooling tower height

*Not likely to be obvious to most viewers.

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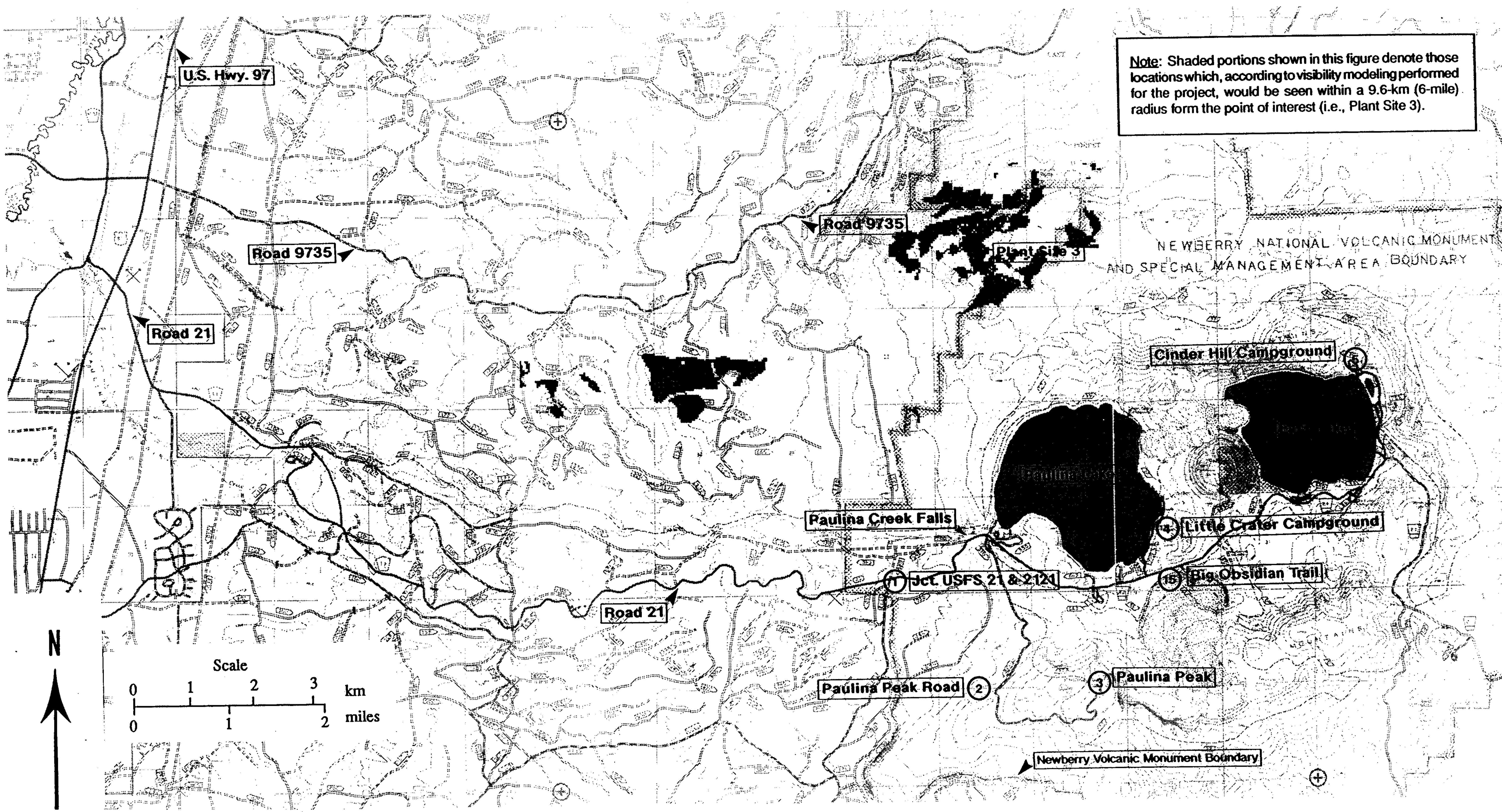
NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Extent of Visibility Field for Plant Site 3	Figure 4.6-14



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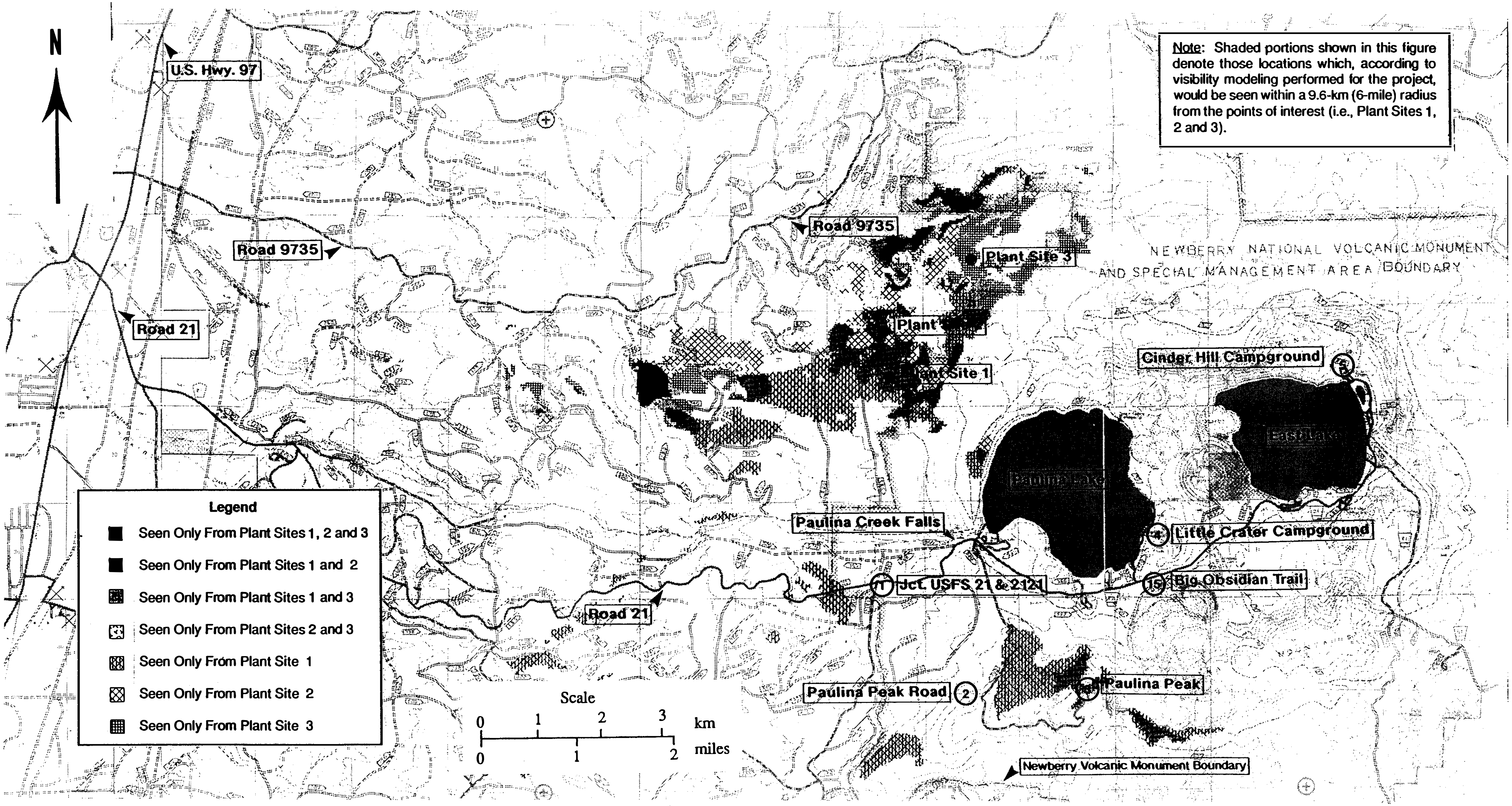
NEWBERRY GEOTHERMAL PILOT PROJECT

Deschutes National Forest, Oregon

Composite Plant Site Visibility Field for Plant Sites 1, 2, and 3

Figure 4.6-15



- Night lighting would be selected and designed to reduce potential visual impacts due to disturbance of the night sky. Exterior lights would be adequate for safe working conditions and security of the facilities.

- Colors of the facility would be chosen to blend with the surrounding landscape.

4.6.6. Additional Mitigation That Could Be Applied to Alternatives A or B

No additional mitigation measures are proposed.

4.6.7. Effects of Alternative C

The no-action alternative would result in no visual change or effects from geothermal activities to current visual resources.

4.7. NOISE

4.7.1. Impact Overview

Noise effects of geothermal projects are commonly divided into three parts. Exploration and development typically are considered together since both involve construction to some degree. Some noise is associated with preparation of the well pads and erection of the drilling rigs, but this construction is generally of short duration as compared to the time required for well drilling and testing (30 to 90 days). Thus, the noise of well drilling (i.e., exploration) is considered dominant because it tends to be of greater intensity and of relatively long duration.

During the development phase, construction of roads, power transmission, and steam lines, and construction of the power plant are also of limited duration. Noise associated with construction of the roads and the transmission and steam lines tends to move to different locations, depending upon where specific activities are located at any particular time. In general, noise from these short-lived construction activities is not considered significant and is not analyzed in detail. For this reason, construction noise is exempted in Oregon's regulations. In contrast, construction of the power plant requires a long time, is at a specific location, and generally requires more heavy equipment than the other types of construction. Power plant construction can last between 6 and 12 months, depending upon when construction begins: i.e., if construction begins in the spring, the shell of the building could be completed before inclement weather arrives, and indoor work could proceed. Noise associated with power plant construction is analyzed below.

The proposed power plant is expected to be operational for at least 50 years and may be considered noisy at nearby locations throughout that time period. However, noise levels from power plant operations at various receptor locations in the Newberry area are expected to be less than ambient noise levels and possibly inaudible, as is described subsequently.

Noise associated with decommissioning of the proposed facility is not analyzed specifically herein, but it is expected to be similar to noise associated with construction of the well pads and the power plant. However, decommissioning is expected to require less time.

Noise levels estimated from the operational segments of the two action alternatives would be less than, and in compliance with, both Federal and state standards.

4.7.2. Method of Analysis

The following assumptions were made and methods used to determine potential noise impacts for both construction and operation. Noise levels associated with well drilling and geothermal operations were based on data gathered from other geothermal energy operations, including The Geysers (Nolte & Associates 1986), Lake County, California; Coso (MHA Environmental Consulting 1988), Inyo County, California; and CIEA's geothermal data files.

4.7.2.1. Noise Estimating Technique

The relevant variables and techniques for estimating noise levels from well drilling and power plant operations are described in detail in the "Power Plant Noise Guide" (Edison Electric Institute 1984). Very briefly, sound propagation is affected by the distance between source and receiver. This distance governs the noise reduction due to both hemispherical spreading and molecular absorption of the sound. The height and location of terrain between noise source and receiver that may function as a noise barrier are also accounted for in the calculations.

4.7.2.2. Assumptions

The estimates of noise levels from construction of a typical well pad or the power plant assumed an equipment assemblage including one large bulldozer, one scraper or large diesel truck, and one cement truck or crane. It was also assumed that, on average, each piece of equipment would generate a maximum noise level of about 83 dBA at a distance of 15 meters (50 feet) one-half the time and would operate at idle the other half.

The drilling rig was assumed to be diesel-electric powered, using bentonite-based muds and four air compressors. Drilling any well was assumed to require 25 to 90 days. Well venting and testing were assumed to be infrequent and limited in duration, but may be as long as 90 days in special cases. During testing, it was assumed that the wells would not be vented directly to atmosphere, rather an efficient muffler would be used.

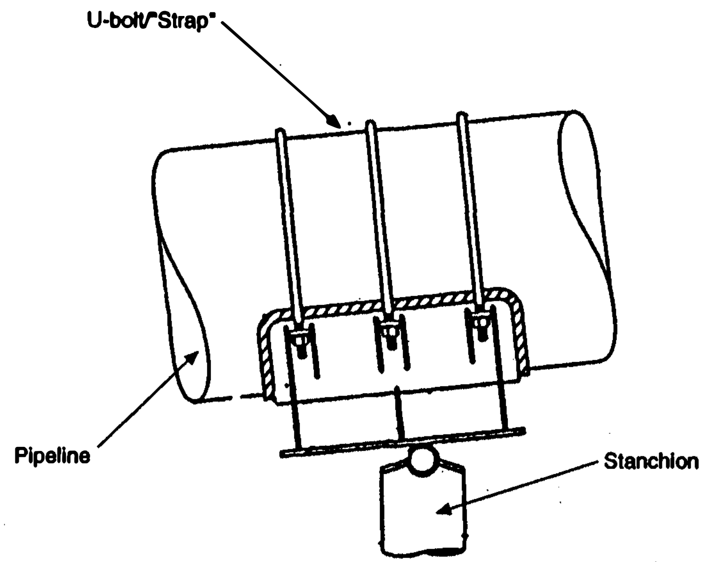
Since the geothermal resource is yet to be explored, steam and water velocities in major pipes cannot be predicted accurately. If these velocities are below approximately 53 meters (175 feet) per second, pipe noise should not be significant. At higher velocities, pipe noise may be significant. However, consistent with Figure 4.7-1, it was assumed that 7.6 cm (3 inches) of insulation would be used on the pipelines and it would effectively reduce pipeline noise. Moreover, only about a 1 psi drop in pressure is expected at the high and low pressure separators in the well field. As a result of these considerations, low noise levels are expected from the wellhead and pipelines.

Analysis of noise anticipated from power plant operation assumed a seven-cell cooling tower system, each tower containing a 150-kilowatt (200-horsepower) electric motor, a 37 MVA transformer, and a turbine-generator building. This building was also assumed to contain other noise-generating equipment, such as an air compressor, air scrubbing system, de-misters, and numerous pumps (Figure 2.4-8). Average noise levels inside this building were assumed to be 85 dBA, which would comply with Occupational Health and Safety Administration (OSHA) noise limits. The building would be designed to accommodate cold temperatures (down to -40°C [-40°F]) and thus is expected to be well-insulated thermally and acoustically with noise absorptive interior walls. Building walls are assumed to have noise reduction properties similar to that of 22-gauge steel.

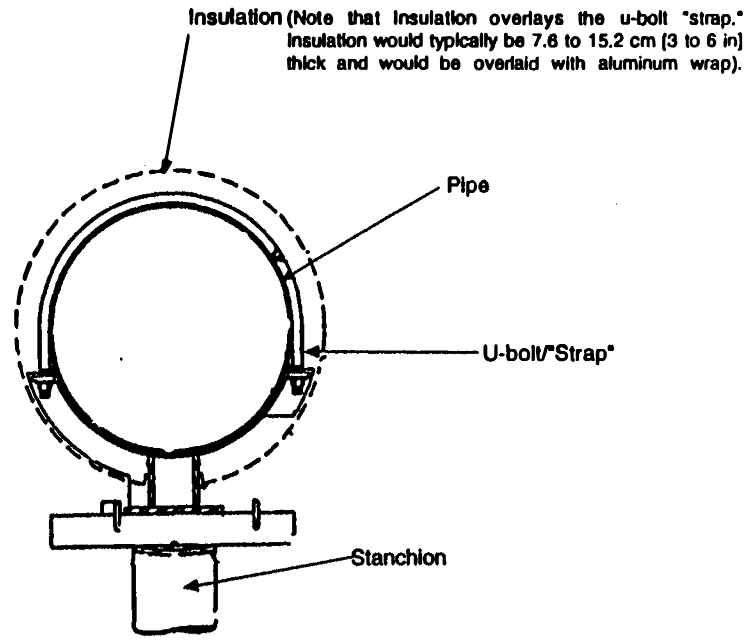
4.7.2.3. Noise Limit Regulations

Both Federal and state noise regulations were used to evaluate estimated noise levels. Federal standards for noise generated from geothermal projects, are in Part 11.C. "Criteria" of U.S. Department of Interior's GRO Order No. 4 (U.S. Department of Interior 1980), the last of a group of orders promulgated in August 1980. The orders state that, in absence of more restrictive criteria, noise at 0.5 mile (0.8 km) from the major geothermal operations shall not exceed 65 dBA. However, if more restrictive state or local regulations exist, these would supersede Federal standards. Consistent with this interpretation, compliance with the state of Oregon's regulations would be required for the proposed project (Felando, pers. comm., 1993).

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Typical Pipeline Insulation	Figure 4.7-1



Side View
(insulation not shown)



Cross-Section

Note: The purpose of this figure is not to show pipeline design specifications. In general, small pipelines would range from 20 to 61 cm (8 to 24 in) and large pipelines would range from 76 to 107 cm (30 to 42 in).

Oregon's Department of Environmental Quality (DEQ) 1983 Noise Regulation exempts sounds originating on construction sites and sounds created in construction or maintenance of capitol equipment. Federal regulations described in GRO Order No. 4 appear to include construction noise under the rubric of "development" activities.

Oregon's regulations refer specifically to "New Industrial or Commercial Sources on a Previously Unused Site." In addition, noise receptors on "Noise Sensitive Property" are defined as locations where people sleep or gather, such as schools, churches, libraries, etc. Noise Sensitive Property, as applied to this project, would presumably include the campgrounds located near Paulina Lake Lodge and elsewhere. A summary of the noise regulations as applicable to the present case is provided in Table 4.7-1.

Table 4.7-1 Oregon's DEQ Noise Control Regulations for New Industrial and Commercial Operations Located on Previously Unused Site

Location of Receptor	Regulation Specifics		Section
Noise Sensitive Property: Real Property used for Sleeping, Schools, Hospitals, Churches, or Public Libraries	Ambient increase $L_{(1)}$ or L_{50}[1] $\leq$ 10dBA AND Between 10 PM and 7 AM[2] L_{50} = 50 dBA, L_{10} = 55 dBA, L_1 = 60 dBA		340-35-035 (B)
At Director's Discretion[3]	10 PM to 7 AM		340-35-035 (f)(A)
At Noise Sensitive Property	Octave Band in hertz[4] (Hz)	L_{50} Not To Exceed	
	63 Hz	62 dB	
	125 Hz	56 dB	
	250 Hz	50 dB	
	500 Hz	46 dB	
	1 kHz	43 dB	
	2 kHz	40 dB	
	4 kHz	37 dB	
	8 kHz	34 dB	

[1]L_1, L_{10}, L_{50}, refer to the noise level exceed 1 percent, 10 percent, or 50 percent, respectively, of the noise measurement time which is specified as any period of 60 consecutive minutes during the 24-hour day.

The predicted or estimated levels from the project are in units of L_{eq}, the Equivalent Sound Level. Power Plant noise is expected to vary little about its median, or L_{50}, and the L_{50} is expected to be nearly equal to L_{eq}.

[2]Only the more restrictive nighttime hours are shown. If these limits are met, it follows that the daytime limits would be met as well.

[3]These discretionary limits may be imposed by the director of environmental quality.

[4]Hertz (Hz) refers to a unit of measurement equal to one cycle per second.

Because of statewide budget cuts, the DEQ no longer has the staff or resources to assist with noise abatement and control. However, the State's noise control regulations are still in effect and provide requirements and guidance to local jurisdictions, who are given authority to enforce the noise standards. Currently, there is no local mechanism for enforcement of the noise standards (Wishart, pers. comm. 1993).

4.7.3. Effects Common to Alternatives A and B

4.7.3.1. Construction-Related Noise

Construction noise generated during exploration and development would include road building, well-pad construction, pipeline installation, and erection of the power plant complex. Dominant noise sources throughout construction would include large diesel-powered equipment such as trucks, compactors, cranes, loaders, etc. Construction activity during these phases is expected to be limited to daytime hours. Many of the proposed well pads are located within 150 meters (500 feet) of the lease boundary, and well-pad construction would thus most likely affect nearby land designated as a No Surface Occupancy area.

During the utilization phase, well pad construction and drilling of new wells would continue to generate noise. Estimated noise levels for construction equipment during exploration and development would be an average noise level of 85 dBA at a distance of 15 meters (50 feet). Extrapolating this average noise level at 15 meters (50 feet) results in an estimated average noise level of about 51 dBA at the 0.8 km (0.5 mile) distance specified in GRO Order No. 4. This level is substantially less than the specified 65 dBA limit. Construction noise is exempted in Oregon's noise regulation.

During exploration, development, and utilization, back-up beepers or alarms would be required on most vehicles and heavy moving equipment for purposes of safety. These beepers generally are loud and are required to be clearly audible over the moving vehicle's own noise and over the noise of other sources in the area. As a result, the distinctive beeping could be audible and prominent several thousands of meters (feet) in distance, even though other construction noise may be inaudible. Also during exploration and continuing through development and utilization, noise from well drilling activities would be limited to the actual boring and casing of the hole. Estimated noise levels at 0.8 km (0.5 mile) from drilling one or two wells are shown in Table 4.7-2. These levels are anticipated to be substantially lower than the GRO Order No. 4 limit of 65 dBA at 0.8 km (0.5 mile), and no impact is anticipated.

4.7.3.2. Drilling Noise

The Oregon noise regulations, as shown in Table 4.7-1, set the permitted maximum (L1) noise level at 60 dBA during the nighttime hours (between 10 p.m. and 7 a.m.). The estimated noise level with drilling of the three wells (Wells M-4, L-4, and K-28) nearest to Paulina Lake Campground would be 34 dBA, or well below Oregon's limit. Moreover, drilling of the well(s) nearest the campgrounds is expected to be less noisy than existing average ambient levels at the campgrounds. For example, ambient noise levels (Average Overall Sound Levels, Table 3.7-1) were measured to be about 29 dBA at the North Cove Campground (located along the north shore of Paulina Lake) while well drilling noise at that location is estimated to be about 10 dB less, at 19 dBA. It is doubtful that drilling noise would be audible if it were 10 dBA less than ambient.

Comparative descriptions of noise outdoors when the levels are low, at 19 or 29 dBA as described above, can be uninformative and misleading, because peoples' experiences and perceptions of quiet situations vary widely. More useful are descriptors of the noise levels associated with mostly indoor devices, as shown in Figure 4.7-2, with which most people have some experience. This figure suggests that the average ambient level, at 29 dBA, in the North Cove Campground is less than that of a freezer and refrigerator at a distance of 1 meter (3 feet), and the estimated well drilling noise of 19 dBA at this campground would be even less than ambient and inaudible.

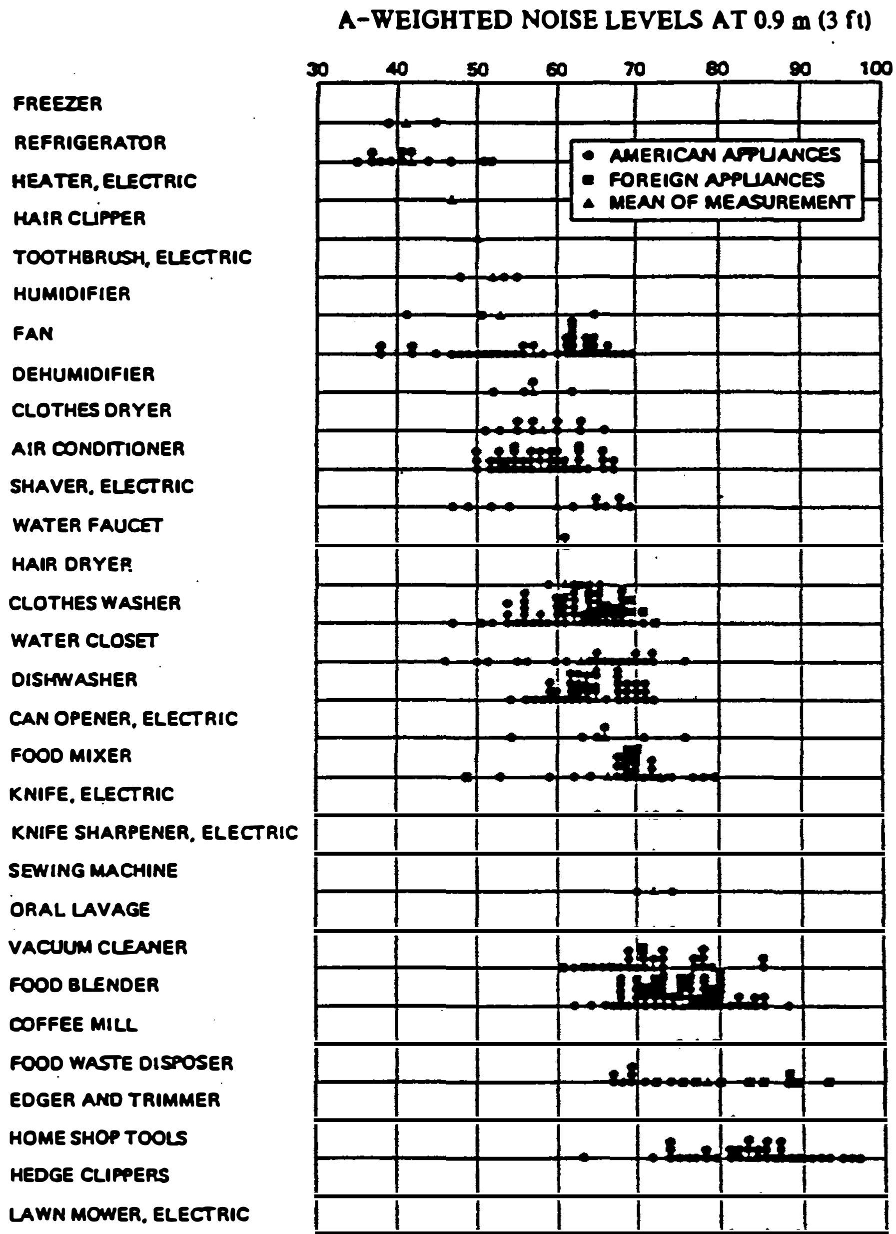
Table 4.7-2 Estimated Sound Levels from Well Drilling at Selected Receptor Locations

Location of Receptor	Well Numbers	Octave Band Center Frequency in dB								Overall in dBA L_{eq}[1]
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
0.8 km (0.5 mile) from a single well	Typical	61	59	49	30	9	0	0	0	45
		No terrain barrier (T.B.)								
0.8 km (0.5 mile) from two wells	B-14	64	62	51	33	12	0	0	0	48
		No T.B.								
North Cove Campground	B-14	34	34	27	13	5	0	0	0	19
		With T.B.; angle = 12.6° for B-14, nearest wall								(39)[2]
Paulina Lake Campground	M-4 L-4 K-28	50	48	38	21	9	0	0	0	34
		With T.B.; Angle = 3.6° for K-28, apparent worst case								(38)
Paulina Lake Campground	M-4 L-4	45	42	32	14	4	0	0	0	28
		With T.B.; Angle ≈ 6° for both								(38)
Paulina Peak	M-4 L-4 K-28	53	52	44	29	18	0	0	0	39
		No T.B.								
Paulina Peak	M-4 L-4	52	51	43	28	17	0	0	0	38
		No T.B.								

[1]The Equivalent Sound Level, L_{eq}, may be thought of as the level of a hypothetical constant sound containing the same sound energy as an actual time-varying sound over a specified time period, generally one hour.

[2]Estimated sound level when thermal inversions occur; worst case is assumed. The total deviation from straight line-of-sight because of the terrain barrier is indicated by the angle.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	A-Weighted Sound Levels at 0.9 meters (3 feet) from Indoor Appliances	Figure 4.7-2



Source: D.N. May (ed.), 1978."Handbook of Noise Assessment." Van Nostrand Reinhold, New York.

As indicated in Table 4.7-2, there may be periods when noise levels generated during exploration and development could increase as a result of sound wave refraction (bending) with thermal inversions. Such inversions and the locations where noise levels may increase are generally unpredictable, but are expected to be more frequent in the early evening and morning hours. Temporary noise level increases due to inversions are not usually considered violations of a noise regulation.

Since the ambient noise level on top of Paulina Peak is expected to be low (about 26 dBA; see Table 3.7-1), drilling of nearby wells during exploration and development could be audible at times. As shown in Table 4.7-2, if several wells (M-4, L-4, and K-28) nearest to Paulina Peak were being drilling simultaneously, noise levels would be expected to be 38 or 39 dBA, or about 13 dB higher than ambient and audible.

Differences in ambient and drilling noise spectra suggest that, if heard, the steady drilling noise may sound like a low-frequency hum or a "rushing" sound. These sounds are not expected to be particularly annoying to people. The clanging of drill pipes and high-pressure air releases are expected to be audible and possibly annoying to observers/recreationists on Paulina Peak and elsewhere. However, campgrounds tend to be relatively noisy at times and, as a result, audibility would depend upon other noisier events occurring coincidentally with pipe clangs. These clanging noises would be intermittent and infrequent and are expected to be a minor impact.

In general, the relatively low overall level and the octave band noise spectra associated with steady drilling noise at the campgrounds would not be sufficient to be considered a violation of Oregon's noise regulations. However, some minor, temporary impacts for some nearby recreationists are anticipated from CEE-proposed construction and/or well drilling activities; these would include short-lived impulsive noises from banging pipes, hammering, high-pressure air releases, etc.

4.7.3.3. Transmission Line Noise

Noise from the 115-kV transmission line in Alternatives A and B is expected to be below background levels.

4.7.4. Effects Specific to Alternative A

Estimated noise levels associated mostly with Alternative A are shown in Tables 4.7-2 and 4.7-3. As described in the preceding section (4.7.3), noise levels associated with exploration, development, and utilization would be similar in Alternatives A and B, since the alternatives include similar activities and activity locations. The major difference between the alternatives would be the specific locations of some particular activities, and consequently their relative proximities to noise receptors.

4.7.4.1. Power Plant Noise

The power plant would begin to generate noise during the utilization phase. Table 4.7-3 summarizes the estimated noise levels from the power plant operations at 0.8 km (0.5 mile), at two campgrounds, and on top of Paulina Peak. Power plant noise is not expected to exceed 65 dBA at a distance of 0.8 km (0.5 mile) (the Federal noise limit) regardless of location. Similarly, the state's night-time limit of L1 = 60 dBA or L50 = 50 dBA is not expected to be exceeded at either of the campgrounds.

Oregon regulation 340-35-035(B) limits the increase to ambient statistical noise levels, L_{10} and L_{50}, at sensitive receptors to less than 10 dBA. Based on baseline noise levels at Paulina Peak, Pauline Lake campground, and North Cove campground (26 dBA, 39 dBA, and 29 dBA respectively), sound impacts of 35 dBA, 48 dBA, and 38 dBA at the respective receptors would be necessary to approach this 10 dBA increase limit. Table 4.7-3 clearly demonstrates that these noise levels are not expected to be reached and the Oregon regulation will not be violated by noise created by plant operation.

Examination of the contribution of the various noise sources to the overall level, indicates that the cooling tower noise would be dominant. Cooling tower noise would be considered a neutral sound, that is, without any apparent tones or whine, and thus, although audible, it is not expected to be annoying to people on Paulina Peak. Operational well pads are considered minor noise sources.

Research on noise and animals indicates that construction, drilling, and power plant complex noise, per se, would have relatively little effect on wildlife (Berglund 1990). General observations suggest that deer and other animals would not be present near highways or at airports if the animals were avoiding the noise. Certainly, noise avoidance should result in fewer roadkills than is typically observed along many busy highways.

Any effect of noise is expected to be more associated with the activities of people rather than the equipment noise of the proposed project with people absent. In addition, some noise is generated by human activities at or near campgrounds (e.g., talking, radios, moving vehicles, wood chopping, motor boats) and nearby traffic and, as a result, the audibility of project noise would depend upon which other noisier events were occurring coincidentally with project noise. It would be speculative to attempt to describe the frequency and loudness of such noisy human activities. However, in general, they are expected to be less apparent at night when most people are sleeping or when people are absent.

Table 4.7-3 Estimated Sound Levels for Power Plant Operations at Selected Receptor Locations

Location of Receptor	Source	Octave Band Center Frequency in dB: 63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall In dBA L_{eq}
0.8 km (0.5 mile) East	Power Complex	51	51	48	44	37	29	0	0	45 dBA
		No Terrain Barrier (T.B.)								
Warm Springs Campground	Power Complex	19	15	10	2	0	0	0	0	5
		With T.B.; Angle = 7.5° for Complex Components								(5)
Paulina Peak Campground	Power Complex	28	24	16	6	0	0	0	0	12
		With T.B.; Angle = 4.0° for Complex Components								(28)
Paulina Peak	Power Complex	32	30	23	13	0	0	0	0	18
		No. T.B.								

Note: Warm Springs campground is defined as a receptor location rather than the North Cove campground; although Warm Springs is about 1,220 meters (4,000 feet) further from the power plant site than is North Cove, the Warm Springs Campground was considered a worst case condition because terrain was expected to be a less effective noise barrier.

In general, noise levels from the proposed complex of power producing equipment would be expected to be low at all receptor locations and also at a distance of 0.5 mile (0.8 km) and is expected to be in compliance with both Federal and state regulations. Impacts on people and wildlife from noise are anticipated to be minor.

Although noise levels associated with construction and operation of the proposed project are anticipated to be low and to comply with both the Federal and state standards, a limited number of noise measurements should be conducted to verify the noise levels estimated herein in order to comply fully with Section 11 of GRO Order No. 4.

In addition, CEE would require that all of its vehicles and equipment and those of its contractors would have mufflers in good operating condition, and this equipment would operate only on existing roads and in approved construction areas.

4.7.5. Effects Specific to Alternative B

4.7.5.1. Power Plant Noise

Two additional alternative power plant sites which are included in this alternative are shown in Figure 2.4-9. Plant Site 2 is about 700 meters (2,300 feet) north of and at the same elevation (about 1,865 meters [6,120 feet]) as the proposed power plant site. It is apparent that implementation of this alternative would move the power plant further from potential noise receptors and reduce power plant noise at those receptors.

Plant Site 3 is approximately 2,256 meters (7,400 feet) northeast of Plant Site 1 and at a higher elevation (near 2,026 meters [6,650 feet]). This location also is farther away from potential noise receptors with a reduction in noise levels at the receptors expected.

The noise levels from the proposed power plant site are estimated to be very low at the receptors (about 18 dBA at the worst case, Paulina Peak, see Table 4.7-3), and so estimation of even lower levels is unnecessary and is not discussed further in this section.

It should be clear, however, that the predicted noise level 0.8 km (0.5 mile) from the power plant (the "Federal" receptor location) would be 45 dBA and would be unchanged with the power plant at either of the alternative locations.

Using the technique described in Section 4.7.1, the noise levels were estimated at the various receptors nearest to alternative well pad locations (see Figure 2.4-19). The results of this analysis are provided in Table 4.7-4. Comparison of this table and Table 4.7-2 (see the "Overall in dBA" columns) shows that the noise levels would change little, and imperceptibly, at receptor locations with the alternative well pads. For example, the largest increase would be about 2 dBA at the North Cove Campground if drilling of Alternative Wells P-15 and O-14 is compared to drilling of a single well at No. B-14. The noise levels are essentially the same (about 19 dBA) if noise from drilling only a single well, No. P-15, is considered.

In general, analysis of drilling noise at the additional well sites in Alternative B indicates that the noise levels at "noise sensitive" receptor locations would not vary widely from the well site locations for Alternative A, and that drilling noise is expected to be usually below ambient noise levels (Table 3.7-1). The estimated noise level at 0.8 km (0.5 mile) from the well pad would be about 45 dBA, regardless of the well pad under consideration. Thus, well drilling noise would not be expected to exceed the "Federal" criteria of 65 dBA at 0.8 km (0.5 mile). Mitigation proposed for Alternative B is the same as proposed for Alternative A.

Table 4.7-4 Estimated Sound Levels from Drilling of Alternative Wells at Selected Receptor Locations

Location of Receptor	Well Numbers	Octave Band Center Frequency in dB 63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall in dBA
North Cove Campground	T-21	33	31	22	5	0	0	0	0	18
				With T.B.; Angle = 13.2°						
North Cove Campground	T-21 S-21	35	33	24	7	0	0	0	0	20
				With T.B.; Angle ≈ 13° for Both						
North Cove Campground	P-15	33	32	24	11	0	0	0	0	19
				With T.B.; Angle 10.7°						
North Cove Campground	P-15 O-14	36	34	26	13	4	0	0	0	21
				With T.B.; Angle ≈ 10° for Both						
Paulina Lake Campground	T-21	40	38	27	10	1	0	0	0	24
				With T.B.; Angle = 4.7°						
Paulina Peak	T-21 S-21	42	39	28	12	3	0	0	0	25
				With T.B.; Angle ≈ 5° for Both						

4.7.6. Additional Mitigation That Could Be Applied to Alternatives A or B

It is recommended that the U.S. Forest Service maintain a log of any noise complaints about the facility. Complaints should be reviewed periodically to ascertain whether the probable noise sources are temporary (sudden, isolated events) or permanent (pipelines or the power plant). If the noise source should appear to be permanent, and complaints are frequent, studies could be performed to identify the specific noise source, and techniques for noise control could be employed.

Careful selection of valve, valve insulation, and "lagging" (thermal and/or acoustical insulation wrapping) of the pipelines should be used in order to reduce noise. CEE's preliminary plans suggest that many of these noise reduction techniques may be implemented. CEE plans to install lagging on the pipelines and to use mufflers at the well pads, as described previously and as shown in Figure 4.7-1 and Figure 2.4-10, respectively. It is premature to specify valves, because the type of valve selected and installed will vary with the velocities and pressures of the materials passing through the valve. Prior to full exploration of the geothermal resource the data required for valve specification is simply unavailable.

4.7.7. Effects of Alternative C

The no-action alternative would result in no change in current noise levels. The existing quiet in the area would continue, and, to the extent that noise and the people making that noise affect the quality of animal habitat, little degradation of habitat quality is expected.

4.8. LAND USE

4.8.1. Impact Overview

Effects on land use that are typically associated with geothermal exploration, development, and utilization fall into one of three issue categories.

The first issue is how the project relates to existing land management policies. In the case of the proposed project at hand, this involves the land use and management policies of the Deschutes National Forest, the Oregon Department of Energy, Energy Facility Siting Council (EFSC), and Deschutes County. Of particular importance to this project is the coordination of project planning with the policies being concurrently developed by the U.S. Forest Service for the NNVM Management Plan.

The second land use issue involves how the project interacts with existing land uses. A direct impact would be if the proposed geothermal project simply displaces an existing land use. The degree of impact would be heightened if that land use could not take place elsewhere. In the case of National Forest lands, a geothermal project could conflict with multiple uses of project lands, such as with timber harvesting or outdoor recreation activities. Reducing the potential for multiple land uses might be related to the timing of geothermal development activities or to security restrictions on access conditions posed by the project utilization. Land use impacts relating to outdoor recreation are discussed in Section 4.9.

The third land use issue deals with the public's perception of land use. As expressed during the scoping process, this issue involves the perception of industrialization of Forest lands. Unlike timber harvest activities, a geothermal project includes the visible construction of facilities and production of noise and odors. These perceptions particularly come into play where existing land uses involve roadless areas and areas that could be potentially designated as Wild and Scenic River corridors.

4.8.2. Method of Analysis

The study area was defined by Forest Road 9720 to the north, the NNVM to the east, Forest Roads 22 and 2225 to the south, and Highway 97 to the west (see Figure 1.1-1). Comprehensive land use plans and management policies were reviewed and analyzed for general consistency relative to the proposed project. These included: the Deschutes National Forest Land and Resource Management Plan (U.S. Dept. of Agriculture 1990a; 1990b); legislation and special management zones definitions for the NNVM (U.S. Congress 1990); alternative land use and management allocations being considered by the Deschutes National Forest for the NNVM Resource Management Plan that is now in preparation; the Geothermal Element of the Deschutes County Comprehensive Plan (1985); and other adopted policies and zoning ordinances.

Recent and proposed timber harvest plans within the immediate project area were reviewed for their areal extent and relationship to the proposed project.

The following elements are part of the overall project description:

- There would be no crossing of Paulina Creek or Road 21 by any project- related access roads, pipelines, or transmission lines.
- There would be no project facilities in the Special Management Area.
- No surface disturbance will be allowed on slopes in excess of 50 percent.

- Roads and all developed project areas, including the power plant site, well pads, pipeline corridors, and transmission line area will be obliterated and restored to a natural setting according to U.S. Forest Service standards, once the project is decommissioned, or if individual roads are deemed unnecessary.

Land use impacts are considered and evaluated to determine if implementation of the proposed project directly contradicts adopted policies contained in the Deschutes National Forest Land Resource and Management Plan (U.S. Dept. of Agriculture 1990a; 1990b), the Newberry National Volcanic Monument Act (U.S. Congress 1990), or other responsible land managing agencies' plans and policies for the area.

4.8.3. Effects Common to Alternatives A and B

4.8.3.1 Adopted Land Use Policies

Deschutes National Forest Land and Resource Management Plan. Table 4.8-1 overviews the relationship between the proposed project alternatives and the land use and management allocations contained within the Deschutes National Forest Land and Resource Management Plan. Public concern was expressed through the scoping process about the intrusion of an industrial land use into an area that historically has been non-industrial. Project exploration, development, utilization, and decommissioning is consistent with the Forest Plan and the allocations within it (see also 4.9.3.1, The Recreation Experience).

The following mitigation measure would be used to reduce adverse impacts:

- Project planning, design, exploration, development, utilization, and decommissioning would comply with the requirements of the Deschutes National Forest Land and Resource Management Plan. These requirements include those outlined in the Memorandum of Understanding for complying with the Deschutes County Year 2000 Plan between the Deschutes National Forest and Deschutes County.

North Paulina Roadless Area. Project exploration and development would involve the clearing of forest areas and the construction of up to 11 production well pads, associated cross-country piping systems and access roads in a portion of the North Paulina Roadless Area (RARE No. 06196). Approximately 525 hectares (1,297 acres) or 6 percent of the 8,750-hectare (21,622-acre) Roadless Area are included in the geothermal leases for the Project Area. This is the gross lease area within the unroaded area, not the amount of land that would actually be disturbed by project activities. Of these lands, the project exploration, development, utilization would physically reduce the size of the North Paulina Roadless Area by a net amount of approximately 65 to 91 hectares (160 to 225 acres). These lands were allocated under the 1990 Forest Plan to manage for Scenic Views (MA8). Removal of timber for geothermal access is allowed under the Scenic View allocation, and geothermal development is allowed as long as visual objectives are met.

The ROS classification for this portion of the project area is Semi-Primitive Motorized (winter only). This inventory would change to Roaded Natural as geothermal exploration and/or development proceeded. The sights, sounds and odors generated by project exploration, development, utilization, and decommissioning would reduce the opportunity for a moderate sense of solitude now afforded by this portion of the Roadless Area. This reduction in the Forest visitor's experience could occur over a greater areal extent than the actual physical presence of facilities. (See also 4.9.3.1, The Recreation Experience, and Section 4.7, Noise Impacts.)

Considering that the vast majority of this Roadless Area is now within the Monument, the limited amount of net acres this project would disturb, and the low potential for wilderness as described in the Forest Plan, this project would not be expected to have a significant adverse impact on the overall recreational opportunities or resources of the North Paulina Roadless Area. Mitigation measures such as limiting public access on new roads into this area would further reduce impacts.

Table 4.8-1
Project Features and Management Designations

Project Feature Alternatives A & B			Resource Management Area Allocation[1]	Recreation Opportunity Spectrum Allocation	Within North Paulina Roadless Area
Main Access/Road 9735			Roaded Natural and General Forest and Scenic Views	Roaded Modified and Semi-Primitive Motorized (winter only)	No
Well Pads and Associated Access Roads/Cross Country Piping System	A-11 B-14 C-15 D-15 E-15 F-22	O-14 P-14 Q-15 R-21	Scenic Views	Semi-Primitive Motorized (winter only)	Yes
	G-21 H-21 I-28 J-28 N-28	S-21 T-21	Scenic Views	Semi-Primitive Motorized (winter only)	No
	L-4 M-4 N-9		General Forest	Roaded Modified	No
Power Plant	Proposed Site (Plant Site 1)		Scenic Views		No
	Plant Site 2		Scenic Views		No
	Plant Site 3		Scenic Views		Yes
Transmission Line Area	Proposed Route		General Forest and Scenic Views		No
	Alternative Route		General Forest and Scenic Views		No

[1] Land Resource and Management Plan and Appendices, Deschutes National Forest 1990.

South Paulina Roadless Area. The small portion of this Roadless Area that is included in the geothermal leases for the Project are within the "no occupancy" SMA. Site disturbance from the geothermal project will not impact the South Paulina Roadless Area.

Paulina Creek Wild and Scenic River Status. Project exploration, development, utilization, and decommissioning would not detract from the eligibility of Paulina Creek as a Wild and Scenic River. No aspect of the project would preclude the management of the Paulina Creek corridor in meeting the standards for recreational sections of the Wild and Scenic Rivers as set forth in the Forest Plan (see also Section 4.9.3, Paulina Creek and Related Access).

4.8.3.2. General Forestry

Between approximately 73 and 109 hectares (180 to 270 acres) would be removed from the supply of land now available for scheduled timber harvesting on the Deschutes National Forest during project development and utilization. This acreage does not include lands within the North Paulina Roadless Area (see also Section 4.8.3, North Paulina Roadless Area, for explanation).

Variables that would effect the amount of lands that would be removed from scheduled timber harvesting include: number of well pads located outside the North Paulina Creek Roadless Area; transmission line routes; power plant location; and size of fire buffers around project facilities.

It is estimated that approximately 1,500,000 board feet of timber could be harvested from areas cleared for the projected project. This figure was derived on the assumption that approximately 119 hectares (295 acres) would be disturbed by the project and 5,100 board feet per acre (2,064 board feet per hectare) would be harvestable. This is a maximum estimate because some of the area to be affected by the proposed project has recently been harvested. The 5,100 board feet per acre estimate is based on studies performed for the Fishhook Timber Environmental Assessment (U.S. Department of Agriculture 1991). Timber which is merchantable would be sent to a lumber mill and the U.S. Forest Service would be compensated for this timber at market value. That timber which is not merchantable would be managed according to U.S. Forest Service harvest policies including distributing designated amounts of slash around the project site and burning portions of slash.

Relative to the overall supply of timber areas on the Deschutes National Forest, these impacts are considered minor. Decommissioning the project would permit all project-related lands to be returned to other forest uses, including timber production.

4.8.3.3 Fuelwood Gathering

Fuelwood gathering would continue to be managed and permitted throughout the project area in accordance with the firewood program at the Fort Rock District. No impacts to current use of the forest would occur from any phase of the project except for the removal of vegetation as described above.

4.8.3.4 Newberry National Volcanic Monument Management Plan

The DEIS for the NMVM was reviewed to evaluate the potential for consistency and conflict between the proposed project action alternatives and the three management alternatives being considered for the NNVM. In general, through effective site planning each alternative being considered for the Monument could likely avoid any significant conflicts with the proposed geothermal action alternatives.

The following mitigation measure would be used to reduce adverse land use impacts:

- Project planning and exploration, development, utilization, and decommissioning would be consistent with the NNVM Management Plan to the extent required by the Monument legislation.

Additionally, geothermal development could be displayed and interpreted as part of the NNVM educational programs describing the geology, volcanism, and natural resources of the area.

4.8.4. Effects of Alternative A

Construction and utilization of the transmission line parallel to Forest Road 9735 for an approximate 9.7-km (6-mile) length would be readily evident to the Forest visitor travelling on this road. This is consistent with the Deschutes National Forest Land and Resource Management Plan allocation of General Forest (M8) through which the transmission line passes. This allocation emphasizes timber production while providing for forage production, visual quality, mineral use, wildlife habitat, and recreation opportunities for public use and enjoyment. From a recreation perspective, the access road is principally within the "Roaded Modified" ROS allocation. That allocation includes "considerable evidence of others" (see also Section 4.9.3.1, The Recreation Experience; and Section 4.6, Visual Resources)

4.8.5. Effects of Alternative B

Development and utilization of Plant Site 3 would encroach into the North Paulina Roadless Area. Compared with Plant Sites 1 and 2, this action would decrease the areal extent of the Roadless Area by an additional 9 to 12 hectares (22 to 30 acres) (see also North Paulina Roadless Area).

4.8.6. Additional Mitigation Measures

The following mitigation measures could be used to further reduce adverse impacts:

- To avoid conflict with scheduled timber harvests, scheduling of project exploration and development activities would be coordinated through the U.S. Forest Service with the schedules of the Fishhook LP Salvage and Prairie Dog Sales.

- Facilities would be located to the greatest extent possible in areas where timber harvesting has already removed the timber. Siting will also be directed to areas of less vegetation and areas with dead stands to reduce impacts to the timber resource.

- Mixed conifer stands would be avoided whenever possible.

4.8.7. Effects of Alternative C

Not implementing project exploration, development, utilization, and decommissioning would result in the Deschutes National Forest not attaining the Forest Land Resource and Management Plan goal of providing for the production of energy resources on the forest.

4.9. RECREATION

4.9.1. Impact Overview

Outdoor recreation is one of many uses of forest lands. The effects on outdoor recreation that are typically associated with geothermal project exploration, development, and utilization are similar to the effects on other land uses (see Section 4.8.1, Land Use). First, these effects could involve the displacement of existing developed or dispersed recreation opportunities, including both summer and winter trail uses. Displacement of recreation features could occur if (1) the location of geothermal facilities coincides with recreation facilities, (2) project utilization changes the water temperatures of surface geothermal springs, or (3) the project closes existing public access for security reasons during project utilization.

There could also be direct beneficial effects to outdoor recreation related to geothermal project development. For example, geothermal development involves the construction of roads and clearing of forest lands. These actions could enhance public access opportunities. Indirectly, game populations could be enhanced by the increased forage supply, benefiting hunters.

Lastly, geothermal exploration, development, utilization, and decommissioning could change the overall experience of the forest visitor. Though ephemeral and likely affecting only a few visitors to the Monument at any one time, there could be times when the project's presence would be seen, heard, and smelled from nearby lands. These sights, sounds, and odors could potentially conflict with the anticipated recreation experience available on nearby lands or at popular vista and destination points. It also could contribute to the experience if tours or interpretive displays are available to the public.

4.9.2. Method of Analysis

The study area was defined by Road 9720 to the north, the NNVM to the east, Forest Roads 22 and 2225 to the south, and Highway 97 to the west. Use records for developed recreation sites (Federal and state) in the project vicinity and region were collected and evaluated. Dispersed recreation use was documented through estimates provided by the U.S. Forest Service and through interviews with U.S. Forest Service personnel. Limited winter and summer season field observations were conducted to validate dispersed recreation patterns identified by the U.S. Forest Service. Recreation use trends were identified and compared with previous projections such as those contained in Demand for Recreation at the Newberry Crater (ECO Northwest 1989).

From a recreation perspective, the following elements are assumed to be a part of the overall project description:

- Nonmotorized public access would not be prohibited from the project area except for the immediate lands of the power plant. This was a concern expressed during the scoping process.
- Nonmotorized public access would not be seasonally restricted.
- Project-related access for construction and utilization would use Road 21.
- There would be no crossing of Paulina Creek or Road 21 by any project- related access roads, pipelines, or transmission lines.

Project impacts would be considered detrimental to recreation resources if:

- The location of proposed geothermal facilities coincides with existing recreation trails or facilities.
- Dispersed recreation activities would be precluded and could not take place within a 8-km (5-mile) radius from the project.
- The sights, sounds, or odors emanating from the project would be sufficient, individually or combined, to detract from the visitor's recreation experience at the NNVM relative to the values expressed in the Newberry National Volcanic Monument Act (U.S. Congress 1990). These values are: the conservation, protection, interpretation, and enhancement of its ecological, botanical, scientific, scenic, recreational, cultural, and fish and wildlife resources.

These issues are discussed in the following text sections.

4.9.3. Effects Common to Alternatives A and B

Direct effects from project alternatives are generally the same on the recreation resources of the forest. Except for the development and utilization of the transmission line, project exploration, development, utilization, and decommissioning of facilities would not present any significant differences relative to the recreation use levels or patterns of use in the project area.

4.9.3.1. The Recreation Experience

Existing recreation activities that would have direct contact with the proposed project facilities are hunting and snowmobiling. For hunters who might now frequent the area, if an increase in the presence of game was a result of the project (due to new forage areas created by site disturbance, transmission, and pipeline corridors, and the presence of new water sources, if required as a mitigation measure), this would likely be considered a net benefit, even if the foreground setting included an industrial-appearing facility. For snowmobilers, who have the ability to travel great distances, the geothermal project, given its location, would likely be seen as a feature near the beginning of a trip along a trail to more remote areas. In short, any changes in the recreation experience to hunting and snowmobiling activities would be consistent with the Roaded Modified or Semi-Primitive Motorized (winter only) ROS designations assigned to the project area.

The following mitigation measure could be used to reduce adverse impacts on the recreation experience:

- Any recreation trails which may be planned in the future would be located to avoid the geothermal facilities.

For some local residents and forest visitors, the perception of the Deschutes National Forest and the project area is one of open forest lands whose principal use is, or should be, open space and recreation.

A forest visitor's experience is made up of a variety of factors. Based on the type of activity, particularly regarding recreation, these factors are the overall character of the setting as defined by its sights, sounds, and air quality; the size of an area and the ability to gain a sense of remoteness; and the amount of direct contact that takes place with others or the evidence of others having been there. Some Forest visitors would also enjoy learning about Forest activities or resources and spending time at visitor centers or other facilities.

The sights, sounds, and smells of the proposed project present a positive opportunity to interpret the region's geologic formations. Though ephemeral and likely affecting only a few visitors to the Monument at any one time, there would be times when the project's presence would be seen, heard, and smelled.

Sight of Steam Plumes. For some forest visitors, the proposed geothermal project would affect their overall experience by adding steam plumes rising from the flanks of the Caldera into the middleground and background views (see also Section 4.6, Visual Resources, for more detailed description and visual simulations).

The visual presence of steam plumes could be interpreted in one of two ways. First, steam plumes may be perceived as a visual reminder that the National Forest is managed for a variety of purposes, which include harvesting natural resources for human use. In that sense, recognizing the presence of the geothermal project, as evidenced by steam plumes, would be akin to being reminded that timber harvest activities take place in the forest as evidenced by the visible contrast of recent timber harvest areas readily seen from Highway 97.

Second, steam plumes could be perceived as a visual key that the Newberry area and the entire Cascade Range is an active, not passive, geologic resource. This perception would be particularly striking for the tourist who has only a basic understanding of the volcanic character of the region and has no knowledge of the geothermal project. In this sense, visibility of steam plumes would present a useful opportunity to the U.S. Forest Service's interpretive program in explaining the forest story.

Sight of Project Facilities. Except for the Alternative A transmission line route (see Section 4.8.4, Land Use) and visual presence of steam plumes, proposed project facilities would not be readily visible from Highway 97, Road 9735, or any developed recreation areas. In the summer, with the exception of Forest Trails No. 57 and No. 51 that access Paulina Peak, project facilities would not be seen from trails or dispersed recreation areas. From Paulina Peak, middleground views to portions of the power plant site and its facilities are likely (see Visual Resources, Section 4.6 for a detailed description of impacts and proposed mitigation measures). Approximately 2 percent of all visitors to the NNVM frequent Paulina Peak. The panorama afforded from Paulina Peak currently includes middleground views to developed features such as Paulina Lodge and Highway 21. Views to any power plant structures could be a distraction from the visitor experience by cumulatively diminishing the sense of seclusion and distance from civilization's trappings.

The following mitigation measure would be used to reduce adverse impacts:

- Facilities are sited to avoid conflicts with recreational facilities and minimize the visibility of project facilities.

Sounds. The Newberry Caldera and immediate environs are not places of only natural sounds. Motor boats on Paulina and East Lakes, concentrations of people at campgrounds, and vehicular traffic on Forest Road 21 all affect the forest visitor's experience. Sounds associated with exploration and project construction that may be heard are temporal, short-term ones that are considered minor impacts. The intermittent, project-related sounds that may be generated during project utilization are consistent with the portion of the project area with a Roaded Modified ROS allocation and with the Rural ROS allocations assigned around Paulina and East Lakes. Operational sounds are generally consistent with the Roaded Natural ROS allocations that exist around Paulina Lake, East Lake, Paulina Peak, and the Paulina Creek/Road 21 corridor. Taken by themselves, these intermittent sounds would present only a moderate evidence of humans and would not preclude the opportunity to get away from the sounds of people.

Portions of the project area and adjacent lands within the Monument and the North Paulina Roadless Area are assigned a Semi-Primitive Motorized (winter only) allocation. Semi-primitive areas emphasize the opportunity to get away from the sounds of other people. To the extent that operational sounds are heard in the summer months, the project would diminish the recreation values of these lands.

As the entrance to the Newberry Caldera, Road 21 is an important recreation route of travel. A new greeting/portal center in the vicinity of the intersection of Roads 21 and 2121 is a common element in all the alternatives being considered for the Newberry National Volcanic Monument Comprehensive Management Plan. The sights of heavy equipment and other project-related vehicles using Road 21, combined with signs and other vehicular access controls that may be present at the intersection of Roads 21 and 2121, will call to the attention of the forest visitor that geothermal development is active and nearby.

Odors. The odor of hydrogen sulfide in the air is synonymous with geothermal activity. An ambient air quality that contains hydrogen sulfide can presently be experienced in the NNVM around the hot springs located on the north shores of Paulina Lake. Development of well fields would result in new sources of hydrogen sulfide entering the atmosphere.

The release of hydrogen sulfide from project wells would occur during the construction phase when each well is vented for a 30- to 40-day period. During utilization, this activity may occur one to two times a year and last from several hours to several days. Meteorological variables would greatly affect the area that would be exposed to hydrogen sulfide odors.

Project odors could, on occasion and for short duration, be evident from the Newberry Crater Rim Loop Trail, trails to the west of the caldera rim, and the west Monument entrance station to the Newberry caldera. See Section 4.5 for a more complete discussion of air quality impacts.

4.9.3.2. Summer Season Recreation

The proposed project will not directly displace any existing, developed recreation facilities in the project area. The proposed project is not anticipated to cause any noticeable change in dispersed recreation use patterns during the summer. This includes the enjoyment of shallow subsurface fumaroles in East Lake and in the hot springs on the north shore of Paulina Lake (see also Section 3.3, Water Resources). The project would not reduce recreation use levels of the project area or surrounding forest or Monument areas. As an attraction, the proposed project would likely result in a minor increase in visitor use in the project area (ECO Northwest 1989).

As a mitigation measure to reduce adverse impacts, CEE could provide tours of the facilities. In addition, any recreation trails which may be planned in the future would be located to avoid possible conflicts with the geothermal facilities.

Paulina Creek and Related Access. Paulina Creek is most often seen by the forest visitor from trails that parallel the creek. These trails consist of the Peter Skene Ogden National Recreation Trail (Forest Trail No. 56) and the Paulina Falls Trail (Forest Trail No. 54). The Paulina Falls Trail leads to the Paulina Falls vista point on the south side of the creek. Other creek access points are at the McKay Crossing Campground and at the Peter Skene Ogden Trailhead.

The power plant site is approximately 2,590 meters (8,500 feet) to the north of Paulina Creek and approximately 3,048 meters (10,000 feet) from Paulina Falls. Well pad No. K-28 is approximately 701 meters (2,300 feet) to the north of the creek and 610 meters (2,000 feet) from the Peter Skene Ogden National Recreation Trail. Forest conditions along the creek and trail corridor are such that the no project facilities would be seen from the creek or trail.

For a minimum of 4.8 km (3 miles) downstream from Paulina Falls, the cascading stream is the dominant sound along the Peter Skene Ogden National Recreation Trail. Sounds from the power plant and other project facilities during project utilization would not affect the visitor experience nor attributes of Paulina Creek that make it eligible for the Wild and Scenic status (see also Section 4.7, Noise). It was observed from the Peter Skene Ogden National Recreation Trail during high spring flows, that the sounds of truck traffic along Road 21 could be intermittently noticed over the constant sound of Paulina Creek. The addition of project-related truck traffic to access well pads L-4, M-4, and N-9, to the extent that it increases overall use of Road 21, will also increase the perception of the road's presence along the Paulina Creek corridor as seen from the Peter Skene Ogden National Recreation Trail. However, increased noise along the Creek generated by traffic along Road 21 is consistent with the minimum management standards for recreational sections of Wild and Scenic Rivers as called for in the Forest Plan. It would be likely that construction and drilling activities at well pad No. K-28 would also be noticed from the trail. However, these sounds would be temporary.

Winter Use. The proposed power plant site and well pad No. T-21 are located along Snowmobile Trail No. 64. In addition, there is a potential reduction of 14 hectares (35 acres) in snow play area that may be caused by the location of the power plant. However, relative to the existing snow play opportunities available in and around the project area, this reduction is considered insignificant. Commercial snowmobile tours do not ordinarily use Trail No. 64, preferring to take a loop route that travels via North Paulina Peak around the caldera and to the numerous snow play areas both on the north and south sides of the caldera flanks.

The action alternatives could result in a minor, beneficial effect on snowmobiling and Nordic skiing opportunities. Transmission line and pipeline clearings would provide additional linear travel options. Winter clearing of the proposed power plant access road would encourage casual exploration by recreationists interested in either snowmobiling or cross-country skiing.

As a mitigation measure to reduce adverse impacts to winter recreation where pipeline crossings of snowmobile routes are necessary, bridges or expansion loops would be constructed in the pipeline to allow sufficient and safe clearance for snowmobiles and skiers, or trails would be re-routed.

Economic effects are addressed in Section 3.15, Economic and Social Characteristics. Effects on monitoring of springs and lakes are addressed under Section 4.3, Water Resources.

4.9.4. Effects Specific to Alternative A

Construction and utilization of a transmission line parallel to Road 9735 for an approximate 9.7-km (6-mile) length would be readily evident to visitors on this road. This would reduce the anticipated quality of the forest visitors' recreation experience.

The proposed project would not limit hunting activities except immediately around the proposed power plant. The success of hunting as a recreation activity is directly related to the presence of animals. The clearing of linear road, pipeline, and transmission line areas combined with area clearings for well pads may increase forage opportunities and presence of big game in the immediate project area (see also Section 4.12, Wildlife Resources).

4.9.5. Effects Specific to Alternative B

Mitigation actions identified under Alternative A also apply to Alternative B. Development and utilization of Plant Site 3 will encroach into the North Paulina Roadless Area. This action would not increase the areal extent that the Roadless Area would be reduced in size (see also Section 4.9.3.1, The Recreation Experience). However, compared to Power Plant Sites 1 and 2, this action would introduce a more actively utilized facility into the Roadless Area, thus having a greater effect on the overall recreation experience of nearby lands.

The following measures would be used under Alternative B to reduce adverse impacts:

- The geothermal facility would be available for public tours by appointment.
- Develop displays or other interpretive avenues to provide information to the local population and visitors to the area about the geothermal resource at Newberry, the geothermal project and its facilities, and the management of geothermal on the Deschutes National Forest. These would be available for display at existing facilities such as interpretive centers, visitor sites, etc.
- Construct a new Snow Park at a location which would not conflict with utilization of the geothermal facilities, but would take advantage of plowed access to this area in the winter time. Additional trails could be developed from this location. Site selection, size, design, maintenance, and management would be determined by the Deschutes National Forest, in cooperation with representatives of local Nordic ski and snowmobile clubs, and the operator. Impacts of Snow Park would be analyzed in a separate environmental document.
- Reroute Snowmobile Trail No. 64 as needed to assure continuity of travel.

4.9.5.1. <u>Hunting</u>

The proposed project would not limit hunting activities except immediately around the proposed power plant and the pipelines. The success of hunting as a recreation activity is directly related to the presence of animals. The clearing of linear road, pipeline, and transmission line areas combined with area clearings for well pads may increase forage opportunities and presence of big game in the immediate project area while decreasing its suitability as a result of increased human access to a currently roadless area with some important summer range (see also Section 4.12, Wildlife Resources).

4.9.6. Additional Mitigation That Could Be Applied to Alternatives A or B

The mitigation measures listed below could be used to offset conflicts or take advantage of interpretive opportunities, but are not currently part of either Alternative A or B.

- Provide interpretive information about the geothermal project and safety information relative to winter use near project facilities at 6-Mile and 10-Mile Snowparks and at any new Snowparks that are constructed in the area.

4.9.7. Effects of Alternative C

Not implementing project exploration, development, utilization, and decommissioning would result in no change to the recreation resources or uses of the project area, the NNVM, or the Deschutes National Forest.

4.10. TRAFFIC AND TRANSPORTATION

4.10.1. Impact Overview

Typical traffic and transportation effects of geothermal projects include the need for new roads or improvements made on existing roads for construction and operation of facilities. Access roads would be required for drilling of wells, construction of transmission lines and pipeline corridors, and for operation and maintenance of the project. New roads and road improvements would be at a level similar to roads used for log hauling and crew travel, in terms of right-of-way, clearing widths, surface materials, etc., unless there is a specific project need. Impacts on existing roads and road needs would be minimized by coordinating efforts between planned U.S. Forest Service logging operations and the proposed project.

Traffic impacts are associated primarily with construction activities. During operation, impacts would be limited to staff commuting to work, maintenance activities, and periodic drilling. Compensation for impacts on existing roads would be primarily from taxes and royalties received by the county.

Other traffic effects include access to the project facilities, access on new roads constructed for the proposed project, impacts on recreational activities, and access into currently roadless areas. For safety reasons, access to the project facilities would be discouraged; however, tours would typically be available to the public upon request.

Potential effects of road use for hauling hazardous materials is covered in Section 4.14, Human Health and Safety.

4.10.2. Method of Analysis

Traffic and transportation effects were examined with reference to new surface impacts from road construction, preventing access to recreational opportunities, and increasing levels of traffic beyond Federal Highway Administration (FHWA) standards for intersections.

4.10.3. Effects Common To Alternatives A and B

4.10.3.1. Road Construction and Use

Figures 2.4-2 and 2.4-19 show the locations of well pads, access roads, and power plant site locations referred to herein. During exploration, new roads would be required to reach some of the well pad locations. Each well pad would require access for workers and equipment. Final access road locations would be based on drill pad site selections and coordination with the U.S. Forest Service.

Access to drilling sites north of Paulina Creek would be via Road 9735 to Spur Road 600 and Spur Road 685. CEE would rebuild and improve the 600 to 680 spur roads during exploration to make them accessible year-round. These improvements include widening shoulders, developing turnouts, and improving the ditches for better drainage. Construction of approximately 4.8 to 6.4 km (3 to 4 miles) of new roads would be necessary to access proposed drill pads in a small portion of the North Paulina Roadless Area located in Township 21 South, Range 12 East, Sections 14, 15, 22 (Figures 2.4-2 and 3.10-1). (A description of the Roadless Area can be found in Section 3.8.2, Adopted Land Use Policies). These roads would be constructed as single-lane resource roads with design speeds of 24 to 48 kph (15 to 30 mph), maximum grade 8 to 16 percent, travelway width of 3.7 meters (12 feet), and a minimum 6.7 meters (22 feet) right-of-way for horizontal clearance. Turnouts would be provided on single- lane roads for opposing traffic. Gravel or other road materials necessary for improvement or repair of existing roads would be obtained from existing road material pits with concurrence of the U.S. Forest Service.

Access to the three drilling sites south of Paulina Creek would be via Road 21 or 22 to Road 2121. The well pads south of Paulina Creek would be for testing purposes only during the exploration phase. No development of these sites would occur. No new roads or other project facilities are proposed to cross Paulina Creek, and no development would occur beyond exploratory testing.

During development, access and construction roads would be constructed for the steam gathering and injection pipeline corridors, as well as for the transmission line routes. New roads would be required where existing commercial use or logging roads are not available, and would be made of gravel or other material. Permanent access roads approximately 3.6 meters (12 feet) wide within a 32- to 36-meter (105- to 120-foot) corridor along pipeline routes are generally required for maintenance purposes. In Alternative B, Road 500 would be reconstructed as access for the transmission line and power plant.

Since most roads in the geothermal area are designed as commercial use (logging) roads, they are constructed to handle loaded log trucks and heavy equipment traffic. This results in a reduced need for road development compared with other similar geothermal developments where heavy-duty roads do not already exist.

Some of the well pads are located within or adjacent to planned logging areas and, to the extent practicable, along existing roads. If a well pad could use one of the temporary commercial use roads, the U.S. Forest Service has the option to keep the road open for geothermal development. Because the logging is scheduled to take place and the proposed project would not begin until mid-1994, there should be minimal conflict between logging and geothermal development.

As far as practicable, all access roads would be routed to avoid new road construction through existing cleared areas and along existing commercial use roads. Because the project vicinity already contains many roads developed for logging, and because commercial use roads would be used to the extent practical, the increase in unpaved road surface due to construction and operation needs would be lessened.

Dust abatement measures would be used to minimize dust and road damage. Application of water, lignin, or other adhering compounds with an oil base could be used.

The main access road and the local spur roads to production well pads would be plowed in the winter. Roads not used for production would not need to be plowed. All roads planned for continuous access during the winter would be surfaced with aggregate or cinder.

No surface disturbance would be allowed on slopes in excess of 50 percent or on designated unstable/very unstable land types without written permission from the Deputy State Director for Mineral Resources, BLM, or the concurrence of the authorized representative of the U.S. Forest Service.

All roads would be obliterated, recontoured, and restored to a natural setting according to U.S. Forest Service guidelines once the project was decommissioned or if roads were deemed unnecessary (i.e., after use).

One-half of the Federal royalties paid by the project would be returned to Deschutes County. These funds could then be used to offset impacts to the local road system (see Economics and Social Characteristics Section 4.15). There could be an overall net benefit to the road systems in the project vicinity from the fees, royalties, and taxes paid by CEE that would go to the county.

CEE would negotiate with the U.S. Forest Service for road construction and maintenance cost reimbursement. A road maintenance agreement would be made between CEE and the U.S. Forest Service, with the intent to maintain Road 9735 as an all-weather gravel-top road for ease of winter maintenance.

Potential effects of road use for hauling hazardous materials is covered in Section 4.14, Human Health and Safety.

4.10.3.2. Traffic

During construction in the exploration and development phases, traffic levels would increase the most. Average daily traffic is expected to be 20 trips per day during construction periods. Road 9735 would be the main access road for construction activities. It is designed to carry log hauls, but is also used for recreational access.

Traffic concerns would focus on the vehicles entering and leaving the intersection of Highway 97 and Road 9735 with some additional traffic at the intersection of County Road 21 and Highway 97 during construction. The traffic at these intersections would vary, depending on the stage of construction of the project. Impacts along County Road 21 would occur only during the exploration phase.

During the exploration phase of the project, one or two drill rigs would be constructed at a time. Each drill rig would require approximately 22 truckloads of equipment to be hauled to the site. Drilling activities would require one to three loads of equipment or supplies per day during drilling and possibly 10 to 15 other vehicles per day visiting the site. A large crane would be used to set the drill rig up and take it down.

During the development phase, traffic would be generated by construction of the transmission line, pipeline corridors, and power plant. During utilization, traffic would be restricted to commuting staff, vendor visits, and maintenance activities.

Traffic increases in the cities of Bend, Sunriver, and LaPine would be restricted to Highway 97. Major construction equipment such as cranes, dozers, and excavators would come to the project area on trucks similar to the mobilization of equipment for new construction in Sunriver or the Pacific Gas Transmission pipeline project.

Most of the materials that would be hauled on the roads are typical of new construction. Except for major equipment such as the turbine, the generator, the condenser, the main transformer, and all main steam separators (which would require special over-size and over-weight permits and flag cars), almost all other equipment packages would come to the site on standard semi-truck loads. Other special loads would involve pipeline materials and transmission line poles, which typically require permits for extra long loads. Excavated materials would not be removed from the project area; therefore, there would be no dirt hauled out on the local road system.

The FHWA has set traffic volume standards upon which intersections are evaluated to determine if traffic signals are warranted. In rural areas such as the intersection of Highway 97 and Road 9735, there would have to be 53 vehicles per hour for an 8-hour period to warrant a signal. This proposed project would not generate vehicular traffic that would approach these levels.

4.10.3.3. Access Restrictions

There would be seasonal vehicular restrictions on accessibility into the project area, and other restrictions may be imposed by the U.S. Forest Service. According to the Road Rules for Commercial Users report (published by Deschutes National Forest, August 27, 1993), the following roads are closed to commercial use and open only for recreational use from November 15 through March 15:

- 2121, from Road 21 to FS 2125
- 2225, from 2121 to 2125
- 9735, from Spur 800 to 9710 (beyond project area)

These roads are shown in Figure 3.10-1.

Public vehicular access may need to be restricted on roads leading to the power plant and well pads at all times during exploration and development. Tours of the plant would be available.

Winter access into the area for power plant operators would be improved by plowing which would be negotiated with the U.S. Forest Service. This has the potential to enhance public use of the area in the winter.

4.10.3.4. Maintenance

During the utilization phase, CEE would have personnel on duty at all times to maintain facilities. The plant would need to be accessible on a year-round basis. With weather permitting, operators would make frequent tours of the well fields to take readings, inspect the equipment, and perform periodic servicing. Roads would be maintained as needed to provide access to production wells.

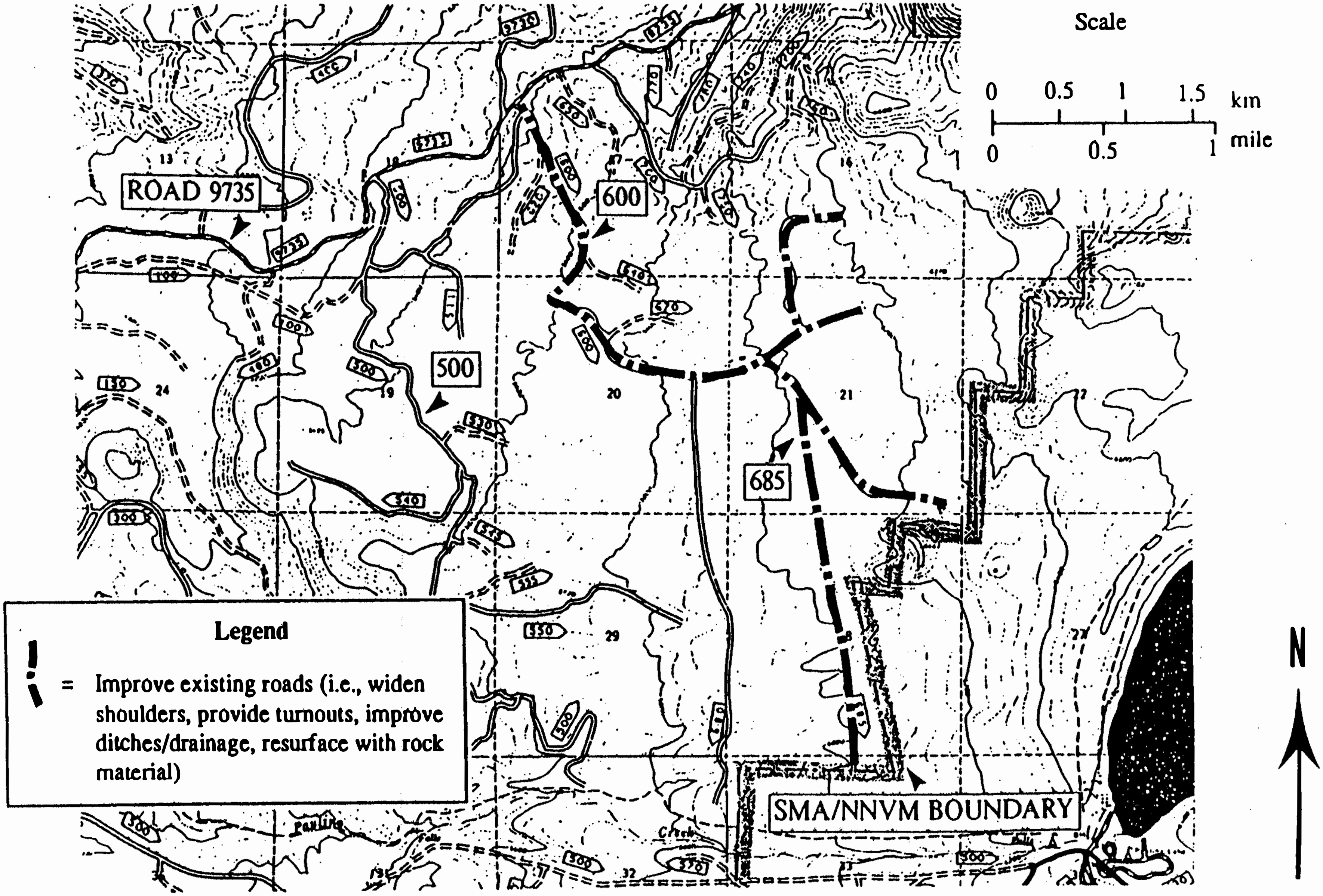
4.10.4. Effects Specific to Alternative A

During exploration, effects of Alternative A would be the same as the effects common to both Alternatives A and B. During development, the transmission line access road would follow Road 9735 and then Spur 600 to the plant. The main entrance to the project area would follow FS Road 9735 to Spur 600 along the proposed transmission line area (Figure 4.10-1).

About 13.7 km (8.5 miles) of a new 115-kV wood pole transmission line would be required. Generally, a 5.5-meter (18-foot) wide permanent access road would be needed the entire length of the transmission line to provide access for maintenance. Road 9735 would serve this need for much of the line length. Conflicts could arise if Road 9735 is widened or modified in the future.

The proposed drilling sites are located within 1.6 to 4.8 km (1 to 3 miles) of existing log landings, skid roads, or otherwise previously disturbed ground.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Improvement, Resurfacing, and New Roads Required for Access Under Alternative A for 9735-500 and -600 Road Systems	Figure 4.10-1



4.10.5. Effects Specific to Alternative B

The primary difference in Alternative B is during development. Road 500 would be resurfaced with gravel and would become the main access road to the power plant (Figure 4.10-2). Access to the transmission line area from Road 9735 would be via short access spurs across existing logging units. Existing logging access spur roads could require extensions of about 0.4 km (0.25 miles) to the transmission line area. Final locations of roads would be based on final engineering design of the transmission line, and the road locations would be approved by the agencies. The transmission line route would be located close enough to Road 9735 to facilitate ease of access during winter maintenance.

By locating the line away from Road 9735, conflicts can be avoided if widening or other design modifications are made to Road 9735 in the future. Access to the three proposed power plant sites would follow Road 9735 to Spur 500 and connect Spur 500 to Spur 600 along the proposed transmission line area. This new Spur 500/600 connection would be upgraded to the same all-weather standards of Road 9735. This connection would require approximately 1.6 km (1 mile) of new road right-of-way along the transmission line and extensive rebuilding of the Spur 600 right-of-way along the transmission line route. Additional new construction would be required to reach Plant Sites 2 and 3. CEE would widen the Spur 500 right-of-way as appropriate for additional turn-outs and drainage improvements.

Access to Plant Site 2 would be along an existing road, which would require additional improvements such as widening shoulders, providing turnouts if needed, improving drainage, and providing a better gravel surface. Access to Plant Site 3 in Section 15 would require approximately 3 km (2 miles) of new road construction.

In terms of construction of access roads to well pads, effects from Alternative B would be essentially the same as Alternative A. The only exception is that additional access road lengths may be necessary to access any of the six alternate well pads if, in fact, they are further from existing roads than the well pads proposed in Alternative A. Also, if well pads are selected under Alternative B that are further from the power plant than those proposed under Alternative A, then a slight increase in transportation impacts would occur from maintaining these wells. Since drilling results may preclude construction of the well pads associated with Alternative A, it is possible that no additional impacts from construction of well pad access roads would occur.

4.10.6. Additional Mitigation That Could Be Applied to Alternatives A or B

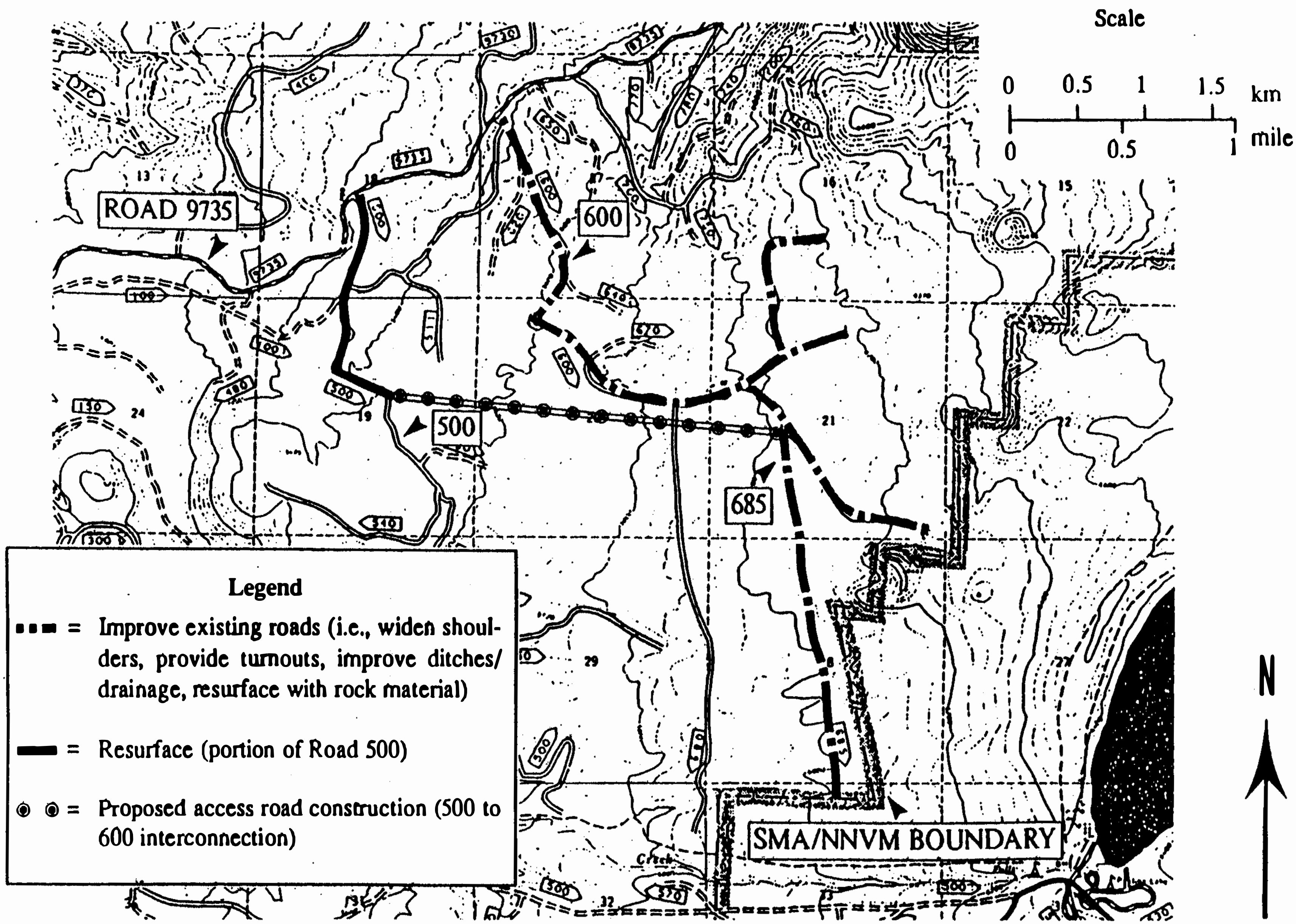
Although it is a permissible use, the Forest Service would not want Road 21 to be the primary access for drilling activity. Alternative routes would be designated . One suggested route could be Highway 97 at LaPine to Road 22 to Road 2225 to Road 2121.

Construction traffic would be restricted to designated roads, which would help reduce erosion, the amount of site disturbance, and would help regulate construction traffic patterns. Any new roads leading into the roadless area would be closed to the public. Closed roads would be signed and may be gated.

4.10.7. Effects of Alternative C

No new effects would occur from development of new roads. Some reconstruction of existing roads would not occur. Additional taxes and royalties to the county for road maintenance would not occur. Local traffic from geothermal development would not occur.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Improvement, Resurfacing, and New Roads Required for Access Under Alternative B for 9735-500 and -600 Road Systems	Figure 4.10-2



4.11. VEGETATION

4.11.1. Impact Overview

Typical impacts to vegetation from a geothermal project would include the direct loss of vegetation from construction of well pad sites, the power plant, pipeline corridors, access roads, and transmission line. Some losses of vegetation could be mitigated in the short-term through revegetation. For example, the project design calls for replanting of the construction area for the pipeline system. Construction would require a broader area for staging pipes and turnarounds, among other needs. Other losses of vegetation would be permanent, such as in those areas cleared for well pads; still others would be long-term losses to be mitigated by revegetation after project decommissioning. During plant operation, potential adverse impacts could occur to vegetation from chemical pollutants released in the power plant plume.

4.11.2. Method of Analysis

Impacts to vegetation are characterized as direct or indirect and long-term or short-term. Loss of vegetation is measured in areas cut by hectare (acre). Direct impacts include the removal of habitat. Indirect impacts are caused by project construction or operation, but are removed in time or space from the project, for example, dust from road building activities would eventually be washed away by rain or wind. Probable impacts from vegetation clearing were identified by superimposing the project "footprint" on existing vegetation communities in the lease area and transmission line area. Other impacts were identified through a review of effects of other geothermal development and a knowledge of other typical construction-related efforts.

Project design calls for project activities to be conducted with as little surface disturbance as possible. Mitigation measures included in each action alternative to reduce the loss of vegetation and sensitive habitats within the project area were considered in the analysis.

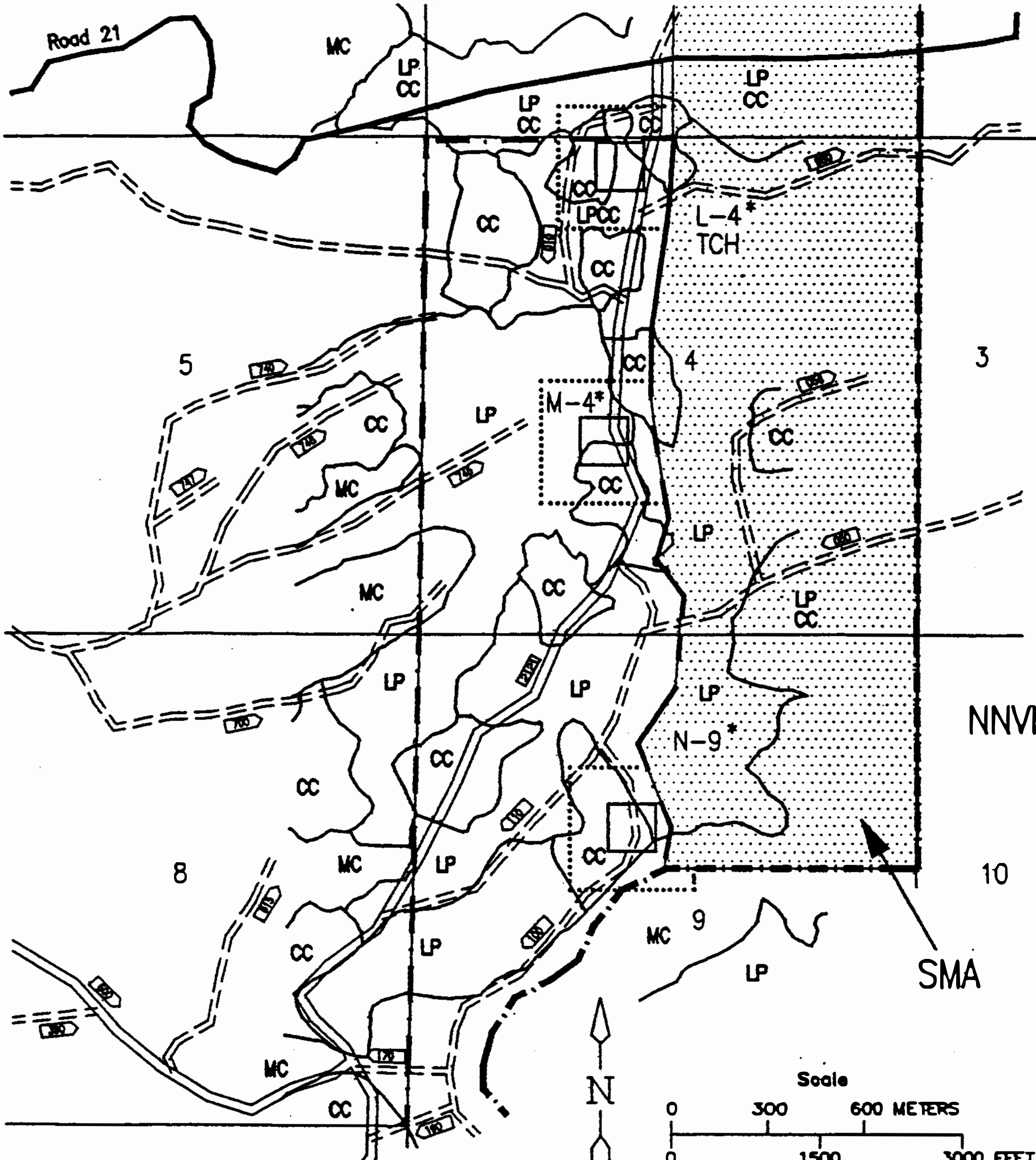
4.11.3. Effects Common to Alternatives A and B

Potential impacts to vegetative cover for both alternatives are shown in Figure 4.11-1 for the Southern Lease Area, Figure 4.11-2 for the Northern Lease Area, and 4.11-3 for the Transmission Line Area.

4.11.3.1. Well Pads and their Access Roads

During exploration, development, and utilization, well pad construction would require the removal of an estimated maximum total of 34 hectares (84 acres) of vegetation and would be considered a direct impact. Access to these well pads would be through the use of existing roads, through disturbed areas, and new roads in the area that is currently roadless in the northeastern part of the surface occupancy lease area. Most of this access road and well pad construction would take place during the exploration and development phases. The main access road to the power plant would require the removal of all vegetation for the road width (6.7 meters [22 feet]) and length over an estimated maximum of 2.2 hectares (5.5 acres). The transmission line would follow the power plant access road, requiring the removal of a total of 6 hectares (14.9 acres) of vegetation along the main access road. Total acreage of forested habitat taken out of timber production for the 14 well pads would be 34 hectares (84 acres). An estimated 4.8 to 6.4 kilometers (3 to 4 miles) of road would be required for well pad access. These access roads would require the removal of up to 7.5 hectares (18.6 acres) of lodgepole pine communities. Approximately one third of the well pad locations (up to 20) have been disturbed by previous logging activities (e.g., Fishhook Timber Sale) (refer to Figure 3.8-2); three will be disturbed by planned logging; the balance are currently undisturbed and are not currently scheduled for future logging.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Vegetative Cover Types In the Vicinity of the Southern Lease Area, Showing Project Features	Figure 4.11-1



Legend

Proposed Drill Pad Location (and 8 to 16-ha [20 to 40-ac] siting area)

Newberry National Volcanic Monument (NNVM) Boundary

Wildlife Study Area and Boundary of SO Lease Area

CC – Lodgepole Pine Regeneration

LPCC – Lodgepole Pine, Seed Tree Type

LP – Lodgepole Pine

MC – Mixed Conifer

Special Management Area (SMA) and NSO Lease Area

* – Well pad for exploration purposes only

NOTE:

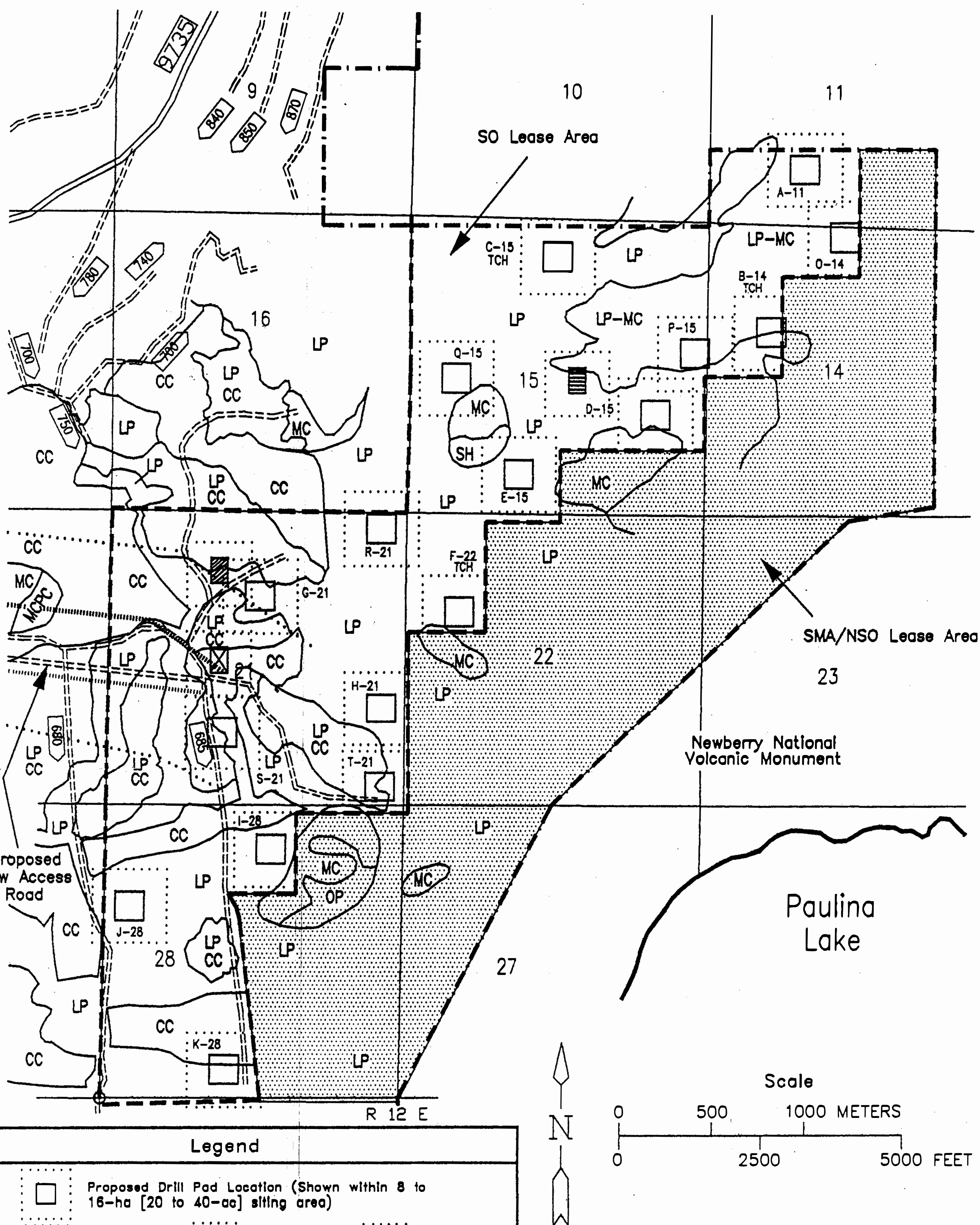
Well pads marked by an asterisk (*) would be for exploration purposes only. There would be no facilities (such as roads or pipelines) constructed across Paulina Creek.

NEWBERRY GEOTHERMAL PILOT PROJECT

Deschutes National Forest, Oregon

Vegetative Cover Types in the Vicinity of the Northern Lease Area, Showing Project Features

Figure 4.11-2



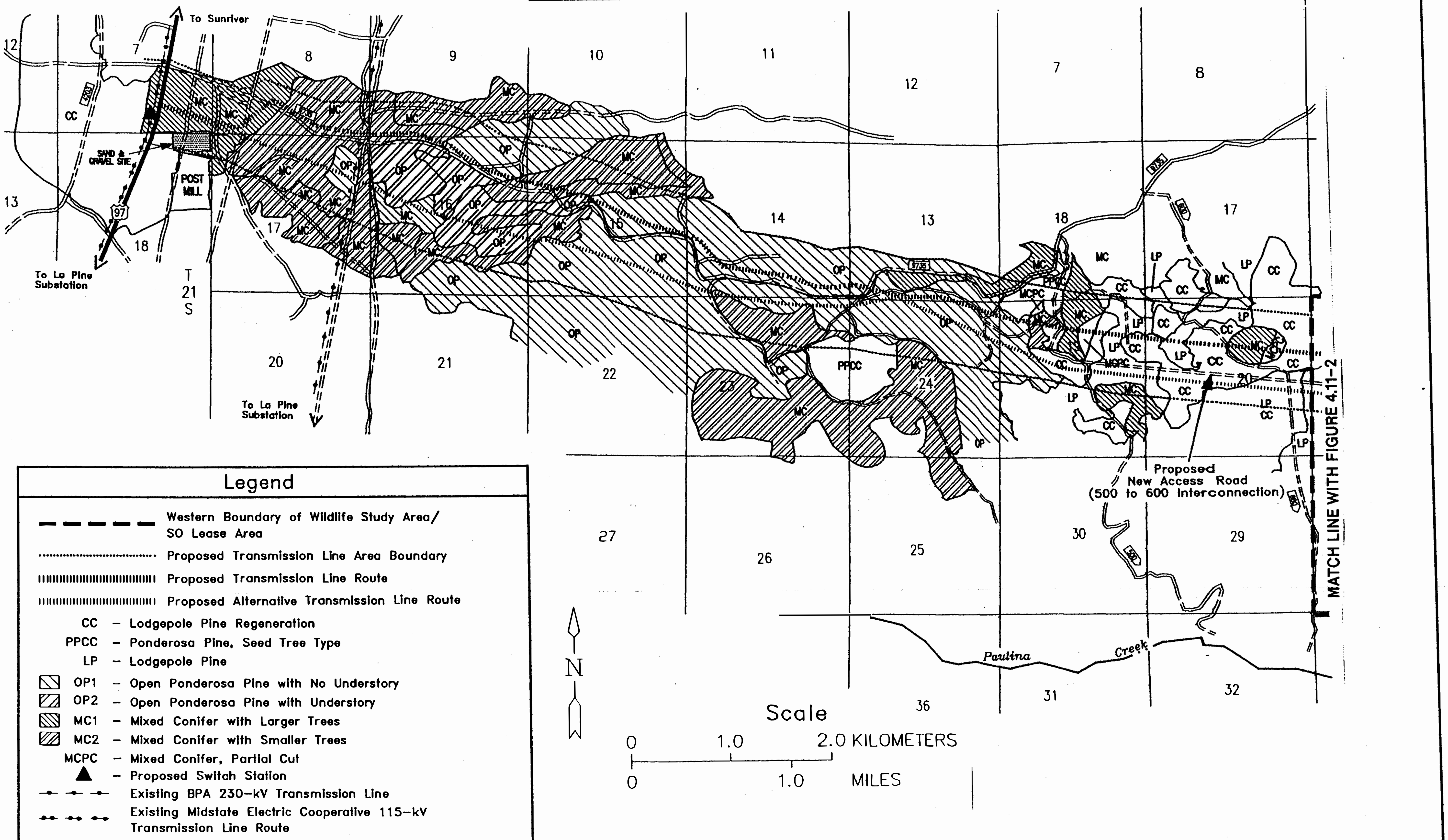
Legend

- Proposed Drill Pad Location (Shown within 8 to 16-ha [20 to 40-ac] siting area)
- Plant Site 1 · Plant Site 2 · Plant Site 3
- (Plant sites shown within 12-ha [30-ac] siting areas)
- Proposed Transmission Line Route
- Proposed Alternative Transmission Line Route
- Newberry National Volcanic Monument (NNVM) Boundary
- Wildlife Study Area and Boundary of SO Lease Area
- Proposed Transmission Line Area Boundary

SH – Shrub, Rock & Scattered Pine
CC – Lodgepole Pine Regeneration
LPCC – Lodgepole Pine, Seed Tree Type
LP – Lodgepole Pine
LP-MC – Lodgepole Dominated with Mt. Hemlock & White Pine
MC – Mixed Conifer
MCPC – Mixed Conifer, Partial Cut
OP – Open Ponderosa Pine
Special Management Area (SMA) and NSO Lease Area

NOTE: The CE Exploration Lease Area consists of the surface occupancy (SO) lease area and the no surface occupancy (NSO) Special Management Area, in which surface activity is not permitted.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Vegetative Cover Types in the Vicinity of the Proposed Transmission Line Area, Showing Project Features	Figure 4.11-3



4.11.3.2. Pipelines

Production and injection pipelines would require a cleared corridor of up to 36.6 meters wide by 6.1 km long (up to 120 feet wide by 3.8 miles long), or 22.7 hectares (56 acres). Additional buffer zones would be roughly 23 meters wide by 4.5 km long (75 feet wide by 2.8 miles long), or 10.3 hectares (25.5 acres). An estimated maximum of 36 hectares (89 acres) would be removed for pipeline corridors (including both main pipelines and feeder pipelines). The majority of the area planned for removal would be lodgepole pine-dominated communities. Estimates for acreages impacted by the pipeline/gathering system are provided under the separate discussions of Alternatives A and B.

4.11.3.3. Main Access Road

Forest Road 9735 would be the primary route of access for both action alternatives. It would have an improved spur off Forest Road 600 and would be finished with aggregate or cinder. Road 500 would be reconstructed for use in Alternative B. The vegetation to be disturbed would consist primarily of lodgepole-dominated areas with portions of open ponderosa and mixed conifer. The areas to be cleared are along an already disturbed corridor.

4.11.3.4. Impacts to Lichen Communities

There would be a direct loss of lichens due to clearing and removal of timber vegetation to make way for construction of project facilities, including roads, pipelines, well pads, and the power plant. Total gross area affected would be the same as those affected by clearing of presently timbered sites for both action alternatives. The actual quantity of lichens removed, however, will depend on the specific site characteristics. The impact to the lichen population of the area as a result of activities associated with either action alternative would be no different from impacts observed in timber harvest operations in which oldest trees are removed. Because most of the construction will take place in previously cleared areas or in the more open timber types, impacts to the lichen community are expected to be small.

4.11.3.5. Air Pollutants

Impacts from project utilization (production activities) may be anticipated from airborne contaminants emitted in the power plant plume, often called drift. Effects of drift on vegetation were monitored at The Geysers and Coso geothermal fields in California. A four-year study at The Geysers found a great degree of variability in boron emissions and deposition at two power plants. Significant increases and decreases were observed in soil boron, foliage boron, and visible injury due to boron (Jones & Stokes 1986).

Long-term vegetation injury could not be projected after The Geysers study for the species studied because of (1) the lack of significant and consistent increases in foliage boron over the full study period, (2) the lack of information on relationships between foliage boron and boron-caused visible injury (i.e., injury thresholds), and (3) the lack of information on soil boron-foliage boron relationships for most of the species (Jones & Stokes 1986).

Deposition, soil, and foliage samples from several sampling locations at The Geysers were analyzed for sulfur, arsenic, and mercury. Sulfate deposition was detected primarily during dry-season periods and at stations that experienced the highest rates of boron deposition. Arsenic and mercury were detected in deposition only at a few stations immediately adjacent to the cooling towers. Levels of the three elements in soil and foliage were generally within the ranges expected for uncontaminated ecosystems (Jones & Stokes 1986).

Effects of cooling tower drift on vegetation were studied at the Navy 1 and Navy 2 power plants at the Coso geothermal field from 1987 to the present. Boron was found to be the only element that occurred in the circulating water in concentrations that could cause effects to vegetation.

Monitoring showed that the concentrations of boron in the cooling tower circulating water were generally below 10 parts per million (ppm). There have been no adverse effects on vegetation and no increases in boron concentrations in nearby soils or vegetation tissue. Because boron levels have remained low, the regulatory agencies reduced the monitoring requirements to monitor only the cooling tower circulating water boron concentrations, as long as the levels remained below 100 ppm.

Vegetation effects from boron at Coso power plants may be less than at The Geysers because the Coso resource produces both steam and hot water and boron is highly soluble and much of the boron remains with the hot water, rather than the steam. At The Geysers, only pure steam is produced and the boron remains in the steam and then the condensate.

Monitoring at Coso showed mercury and arsenic levels in the cooling tower water have stayed at the limits of detection, generally 1 ppm (Leitner 1993).

Lichens are useful indicators of air quality because they can readily accumulate and leach elements from airborne sources. Due to their ability to reflect deposition composition and concentration of airborne contaminants, lichens would be used as an indicator for air pollution impacts on vegetation from project implementation.

Predicted average annual concentrations and land area of coverage of potentially harmful pollutants is low and would not be expected to impact vegetation or wildlife immediately. Impacts could occur during the project utilization phase and be cumulative over time. Airborne contaminants of the greatest concern are mercury (Hg), hydrogen sulfide (H_2S), arsenic (As), and boron (B). Air quality modeling and analysis indicated that total concentrations of boron, arsenic, hydrogen sulfide, and mercury are predicted to be well below Federal standards within 500 meters (1,640 feet) of the power plant in three wind directions and even less in areas further from the plant (See SAIC report in Appendix F). Major air quality impacts to lichens and other vegetation are not anticipated due to the very low predicted levels of contamination. Lichen biomonitoring should adequately test this prediction.

The U.S. Forest Service has initiated a lichen monitoring and study program in the area near the proposed plant sites (three alternatives). Baseline information is being collected, from which to compare any future changes resulting from geothermal operations. Monitoring would continue to be done on a semi-annual basis, during exploration, development, and operational phases. The monitoring consists of establishing transects and a series of plots, from which lichen populations are observed and documentation is made of species present and their health and abundance. This study also includes collection and laboratory analysis of lichen samples for a number of potential elements or pollutants or possible concern. This analysis would help identify which, if any, chemical elements emitted from the power plant need further controls and provide an early detection system of potentially significant adverse types and quantities of pollutants. This monitoring would be in addition to other types of monitoring of emissions and chemistry of the geothermal fluids at the wells and the power plant. Information from these monitoring processes would then be used to help determine if any additional mitigation measures need to be applied.

Impacts to vegetation are described below under each action alternative.

4.11.3.6. Threatened and Endangered Species

Effects on threatened and endangered species have been analyzed in a Biological Evaluation on file at the Fort Rock Ranger District. No impacts are anticipated to any listed threatened or endangered species or to U.S. Forest Service Regional Forester's list of sensitive plants because none are known to exist in the project area. A discussion on the plant community, including sensitive species, within the project area is located in Section 3.11, Vegetation. The additional mitigation measure in Section 4.11.6 will protect any small areas of potential habitat.

4.11.4. Effects of Alternative A

Development of the proposed plant site would take place on 7.5 hectares (18.5 acres) of lodgepole pine habitat (Figure 4.11-2). This area lacks structural diversity (shrub and herbaceous layers are undeveloped) due to natural conditions such as beetle infestation and blowdown, and previous timber harvest entries.

Each of the 14 well pads will be up to 2.3 hectares (5.5 acres) in size, and will require surface clearing. Table 4.11-1 indicates the amount of vegetation in each habitat type that would be affected by well pads for Alternative A. Refer also to Figure 4.11-1 and 4.11-2 for delineation of habitat types.

Exact locations of pipelines and access roads and the exact amount of vegetation in each habitat type for these are unknown until the exploratory phase has been completed. However, Table 4.11-1 provides an estimate of expected impacts by vegetation types.

As can be seen from Table 4.11-1 and Figures 4.11-1 and 4.11-2, most of the proposed well field and plant facilities fall within lodgepole pine types. Refer also to Table 4.12-1 which provides more site-specific information about each well pad and plant site location.

Construction and operation of the proposed transmission line would be partly within the existing Forest Road 9735 cleared right-of-way. The total approximate area which would be cleared of vegetation would be 30.5 meters by 13.2 km (100 feet by 8.2 miles), or 40.2 hectares (99.4 acres). Estimates of areas of vegetation by cover type which would be disturbed by building the proposed transmission line are provided in Table 4.11-1. The transmission line route is shown in Figure 4.11-3.

4.11.5. Effects of Alternative B

Under this alternative, the actual siting of the 14 well pads within the larger study or siting area will be approved by the U.S. Forest Service and BLM after considering on-the-ground factors, such as avoiding any sensitive areas, access options, and the best location with respect to the geothermal resource. This process of siting well pads was developed to best meet the need to minimize site-specific impacts. The analyses of 20 well pad siting areas (from which 14 would be developed for the project), is intended to provide additional flexibility in avoiding any sensitive areas and in allowing the agencies and developer greater flexibility in well pad location. Because there is this flexibility in the actual selection of the well pad site, it is not possible to specifically identify the precise amount of area to be disturbed. This will vary depending on which 14 of the 20 well pad areas are selected, and where within each siting area each pad is sited.

A total of 14 well pads (chosen from the 20 potential locations) would be constructed and would remove approximately the same total area of vegetation as Alternative A. The vegetation impacts could differ slightly from those in Alternative A if one or more of the six locations not included in Alternative A were chosen. The pipeline and access road systems could likewise affect a slightly different amount of vegetation, depending on the specific placement of facilities.

The analysis indicates, however, that the net disturbance as estimated for Alternative A can be reasonably applied as an average expected impact for Alternative B. Different combinations for siting in Alternative B may result in slightly different figures (either higher or lower). However, they are not expected to make a significant difference in the total impacts of the project. Therefore, Table 4.11-1 provides an estimate of average disturbance due to well pad, power plant, pipeline, and access road placement. Refer also to Figures 4.11-1 and 4.11-2 to see facility placement in relation to habitat type. Refer also to Table 4.12-1 which provides more site-specific vegetation information about each well pad and plant site location.

Table 4.11-1
Alternatives A and B
Estimates of Vegetative Cover Types Impacted by Project Implementation

System Component	Applicable Phases	Maximum Width in Meters (Feet) (if applicable)	Areas of Cover/Types Affected hectares (acres)										Maximum Total Area Disturbed
			LP/MC	LP/CC	LP	MC1[1]	MC2[2]	SH	OP	PPCC	CC	MC/PC	
Main Access Road to Power Plant	Exploration, Development, Utilization	18.3 m (60 ft)			1.4 (3.4)		2.1 (5.2)				2.5 (6.2)		6 (14.9)
Well Pad Access Roads for 14 well pads	Exploration, Development, Utilization		1.1 (2.7)	0.49 (1.2)	5.8 (14.4)	0.14 (0.34)							7.5 (18.6)
Well Pads (14)	Exploration, Development, Utilization		3.7 (9.2)	1.4 (3.5)	24.6 (60.8)	0.2 (0.4)					4.1 (10.1)		34 (84)
Plant Site	Development, Utilization				7.5 (18.5)								7.5 (18.5)
Main Pipelines/ Gathering System	Development, Utilization	36.6 m (120 ft)[5]	4.4 (10.9)	2.0 (4.8)	16.1 (39.8)	0.13 (0.34)		0.06 (0.13)					22.7 (56)
Feeder Pipelines/ Gathering System	Development, Utilization		1.1 (2.8)	1.2 (3.0)	10.6 (26.1)	0.4 (1.1)							13.3 (33)
Average Estimated Area Disturbed for Well Field and Plant, by Vegetation Type			10.3 (25.6)	5.1 (12.6)	66 (163)	0.9 (2.2)	2.1 (5.2)	0.06 (0.13)	0	0	6.6 (16.3)	0	91 (225)
			CLR/FTH[3]	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH
Transmission Line Area, Alternative A	Development, Utilization	30.5 (100) CLR 7.6 (25) FTH[3]		1.2 (3)/ 0.45 (1.1)	0.2 (0.5)/ 0.08(0.2)	3.6 (9)/ 1.2 (2.9)	4.5 (11)/ 1.3 (3.1)		13.7 (34)/ 4.7 (11.8)		3.2 (8)/ 1.1 (2.8)	1.6 (4)/ 0.53 (1.3)	28.1 (69.5)/ 9.4 (23.2)
			CLR/FTH[4]	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH	CLR/FTH
Transmission Line Area, Alternative B	Development, Utilization	23 (75) CLR 7.6 (25) FTH[4]		1.5 (3.6)/ 0.97 (2.4)	2.2 (5.5)/ 1.5 (3.6)	2.2 (5.5)/ 1.5 (3.6)	3.3 (8.2)/ 2.2 (5.4)		17.3 (47.2)/ 11.5 (28.5)		3.3 (8.2)/ 2.2 (5.5)		31.6 (78.2)/ 19.9 (49)

1 MC1 high elevation mixed conifer in surface occupancy
2 MC2 lower elevation mixed conifer in transmission line area
3 30.5-meter (100-foot) ("CLR") and 7.6 meter (25-foot) ("FTH") designations refer to construction of the transmission line area; a 30.5-meter (100-foot) swath would be cleared (CLR) and a 7.6 (25-foot) swath on each side of the cleared area would be "feathered" (FTH) for this alternative.
4 23-meter (75-foot) ("CLR") and 7.6 meter (25-foot) ("FTH") designations refer to construction of the transmission line area; a 23-meter (75-foot) swath would be cleared (CLR) and a 7.6 (25-foot) swath on each side of the cleared area would be "feathered" (FTH) for this alternative.
5 This is the maximum width required for mulitple pipelines and expansion loops. A more typical width would be 27 meters (90 feet) or less.
Note: Totals may not agree with sum of components due to rounding off and unit conversions.

Alternative B considers placement of a power plant at either the location described in Alternative A (Plant Site 1), or at one of two additional sites. Plant Site 2 is located north of Pad G-21 (Figure 4.11-2). Construction of this facility would require the removal of 7.5 hectares (18.5 acres) of lodgepole pine and lodgepole pine seedtree (recently harvested stands) vegetation. There are currently extensive stands of this type within the project area (Figure 4.11-2). Plant Site 3 is located northeast of Plant Site 2 (south of well pad C-15) and would require the removal of 7.5 hectares (18.5 acres) of lodgepole pine and limited lodgepole pine/mixed conifer vegetation. The lodgepole pine/mixed conifer vegetation is relatively scarce within the project area.

Siting flexibility as an integral part of Alternative B will help the agencies locate facilities, gathering systems, and access roads in such a way to minimize site disturbance by selecting shorter routes and/or locating operations in areas already disturbed, whenever possible.

The location of the transmission line would be different from that in Alternative A, and would result in slightly different impacts to vegetation. By using the different pole design, the area to be disturbed for transmission line placement is approximately 38.1 meters (125 feet) in width. Of this, 22.9 meters (75 feet) would be cleared of trees, while 7.6 meters (25 feet) on either side would be "feathered" and trimmed rather than cleared. Estimated effects to vegetation from this transmission line are also shown on Table 4.11-1, and the location with habitat types is shown on Figure 4.11-3.

4.11.6. Additional Mitigation Measures

The I-28 pad could also be relocated to the west of the proposed site (Alternative A) and avoid the sensitive mixed conifer vegetation altogether. In addition, construction activities at well pad locations A-11, B-14, and O-14 would avoid disturbing larger trees to the extent possible.

Site-specific pipeline and access road locations will be reviewed by a U.S. Forest Service botanist to avoid potential sensitive plant habitat, as described in the Biological Evaluation.

4.11.7. Effects of Alternative C

Under this alternative the project would not be developed. The area would continue to undergo succession in those stands that have been harvested and the previously sold Fishhook timber sale stands would be cut.

4.12. WILDLIFE

4.12.1. Impact Overview

Impacts to wildlife and wildlife habitat from geothermal development are associated with direct long-term loss of habitat during exploration, development, and utilization phases from well pad sites, power plant sites, transmission line, and access roads. Other potential impacts may occur from wildlife contact with waters at sumps and the power plant water storage pond. Increased public access during exploration, development, and utilization may result in increased road kills of wildlife, and may increase hunting pressure on big game. Off-site impacts could occur during utilization as the result of deposition of airborne pollutants in nearby water bodies with effects on fish and fish-eating wildlife. Displacement of wildlife in response to human disturbance can occur during exploration, development, utilization, and decommissioning activities.

4.12.2. Method of Analysis

Impacts to wildlife are discussed in terms of specific areas that would be modified by project activities and a larger zone potentially influenced by project development. For example, while an individual well pad may require the removal of habitat from only 1.6 to 2.3 hectares (4 to 5.7

acres), other impacts such as noise and other disturbances affect wildlife use over a larger area in the vicinity of the pad. Specific well pad sites 1.6 to 2.3 hectares (4 to 5.7 acres) in size were evaluated for Alternative A. Analysis of Alternative B was different in that well pad siting areas up to 16 hectares (40 acres) in size, within which a 1.6- to 2.3-hectare (4 to 5.7-acre) well pad would be located at a to-be-specified location, were analyzed and any sensitive areas identified. Since exact locations for wells are not yet selected for Alternative B, estimated impacts were given in ranges from the smallest to the largest impact or as the least or greatest impact. Well pad locations within the siting areas would be chosen to avoid sensitive areas and reduce impacts, in consultation with the land and resource management agencies.

Management Indicator Species (MIS), Threatened and Endangered Species (TES), and neotropical migrants (see Section 3.12, Wildlife) are used as the basis for identifying potential impacts from the alternatives. Impacts were defined as short-term or temporary and long-term or permanent, direct or indirect.

General information on plant and animal habitat types were described in Chapter 3. Figures 4.11-1 through 4.11-3, which show vegetative cover types and include project components in the lease area and transmission line area, respectively, are located in Section 4.4, Vegetation. Figure 4.12-1 shows suitable habitat for species of concern as it relates to project components, and Table 4.12-1 summarizes wildlife habitat characteristics for the lease area.

4.12.3. Effects Common to Alternatives A and B

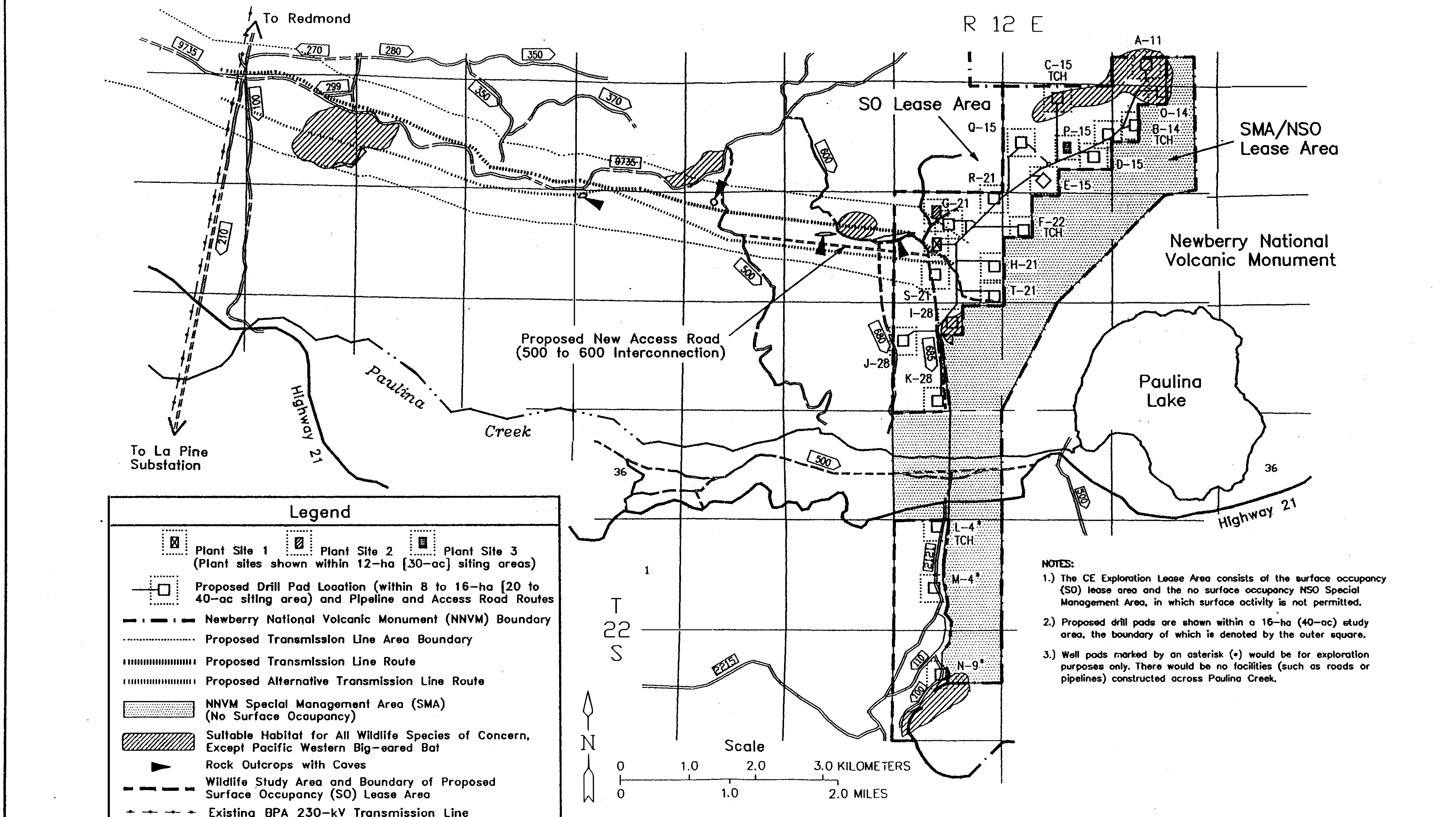
4.12.3.1. Habitat Loss

Up to 227 hectares (560 acres) of the project area could be explored and up to 41.5 hectares (102.6 acres) of habitat would be modified by exploratory drilling and associated activities. Each production-sized well pad would be approximately 1.6 to 2.3 hectares (4 to 5.7 acres) and include small sump ponds. Generally, all project activities would be confined to designated areas to minimize unnecessary surface disturbance. Initial construction noise, dust, and human activity would result in short-term dislocation of sensitive resident wildlife. Most of the drill pad sites are located in thinned or regeneration cut lodgepole pine, with some scattered mixed conifer habitats. A summary of habitat features for the wells and the plant site is shown in Table 4.12-1.

Generally, lodgepole pine communities (LP, CC, and LPCC) provide only marginal habitat for most wildlife species (Figures 3.11.2-1 through 3.11.2-3). However, the lodgepole pine forested habitats (LP) found in the project area are mostly dense, even-aged stands of small diameter trees with herbaceous and shrub layers absent or largely undeveloped and scattered. Many trees within these lodgepole stands are dead or weakened by recent insect infestations and drought. The dead wood component (down logs and snags) is abundant but is small diameter (all less than 10-inch and most less than 5-inch diameter) which is not considered optimum for most species that utilize dead wood for foraging and nesting. Neither the LPCC or the CC habitat types are providing suitable habitat for many wildlife species due to lack of vegetative structure and diversity. Drilling at Pad Sites A-11 and C-15 would result in a direct and long-term loss of up to 5 hectares (12 acres) of a mule deer/elk (MIS) high-use area. This high-use area is an area of good grazing habitat and includes an adjacent area which deer and elk may use for travel to a mineral lick located at the north end of Paulina Lake.

Generally, deer and elk movement is considered to be random and is likely to be dispersed throughout the entire project area; however, road construction, human access, and development at all drill pad sites would result in displacement of these species. Current road density is estimated at 4.3 km/sq km (2.9 miles/square mile), which slightly exceeds the Forest Plan Standard and Guideline of 4 km/sq km (2.5 miles/square mile). Reductions of available cover and forage habitats will differ by each action alternative. These differences are discussed below in Section 4.12.4 and 4.12.5, however, cover to forage ratios will remain the same as existing conditions for each action alternative. While there would be a minor loss of habitat from well pad development, long-term adverse impacts to deer and elk populations in the area are not anticipated.

NEWBERRY GEOTHERMAL PILOT PROJECT Deschutes National Forest, Oregon	Suitable Habitats for Species of Concern, Showing Project Features	Figure 4.12-1



NOTES:

1.) The CE Exploration Lease Area consists of the surface occupancy (SO) lease area and the no surface occupancy NSO Special Management Area, in which surface activity is not permitted.

2.) Proposed drill pads are shown within a 16-ha (40-ac) study area, the boundary of which is denoted by the outer square.

3.) Well pads marked by an asterisk (*) would be for exploration purposes only. There would be no facilities (such as roads or pipelines) constructed across Paulina Creek.

Table 4.12-1
Wildlife Habitat Components by Project Feature

Pad Site #	Cover Type	No. Canopy Layer	DBH Range cm(in)		DBH Average cm(in)		Percent Canopy Closure		Dead/Down Wood	Dead/Down Wood	Snags	Snags Avg. DBH	Percent Bare Ground	Caves	Comments
			Upper	Lower	Upper	Lower	Upper	Lower	Size Range cm(in)	Avg. Diameter cm(in)	#/acre	cm(in)			Varying Canopy Closure, 0 to 100 percent
A-11	LP-MC	3	5.1-50.8(2-20)		23(9)		60	15-30	5.1-71.1(2-28)	25.4(10)	15	27.9(11)	15	None	Third canopy layer is seedling/sapling
O-14	LP-MC	2	5.1-25.4(2-10)		12.7(5)		50	5-10	5.1-35.6(2-14)	15.2(6)	3	20.3(8)	15	None	
B-14	LP													None	Mosaic of habitat types.
P-15	LP													None	Mosaic of habitat types.
C-15	LP	2	7.6-33.0(3-13)	2.5-10.2(1-4)	25.4(10)		35	10	_	_	15	25.4(10)	30	None	
D-15	LP-MC	2	7.6-20.3(3-8)	5-10.2 (2-4)	10.2(4)	7.6 (3)	70		5.1-30.5(2-12)	10.2(4)	3	15.2(6)	5	None	
E-15	LP	1	5.1-25.4(2-10)		10.2(4)		50		5.1-30.5(2-12)	10.2(4)	5	10.2(4)	5	None	Contained a shrub-dominated cover type on south-facing slope of cone
Q-15	LP	3	10.2-20.3(4-8)	5-12.7 (2-5)	15.2(6)	7.6 (3)	5	10	5.1-30.5(2-12)	15.2(6)	25	23(9)	10	None	Third canopy is seedling/sapling
R-21	LP	1												None	
F-22	LP	2	10.2-25.4(4-10)		10.2(4)		25	10-15	5.1-25.4(2-10)	10.2(4)	15	17.8(7)	10	None	
G-21	LP	1	5.1-25.4(2-10)		15.2(6)		25		15.2(6)	15.2(6)	12	15.2(6)	15	None	Pad site partially clearcut
H-21	LP		5.1-25.4(2-10)		17.8(7)		45		10.2-20.3(4-8)	15.2(6)	12	20.3(8)	30	None	
T-21	LP		5.1-25.4(2-10)		17.8(7)		45		10.2-20.3(4-8)	15.2(6)	12	20.3(8)		None	
S-21	LP	1	5.1-25.4(2-10)		12.7(5)		30		15.2-30.1(6-12)	15.2(6)	12	15.2(6)	15	None	Portion of site is clearcut
I-28	LP and MC													None	Mosaic
13-28	LP	2	5.1-25.4(2-10)		15.2(6)		20	10	10.2-35.6(4-14)	20.3(8)	10	15.2(6)	15	None	Portion of the site clearcut
K-28	LP	2	2.5-10.2(1-4)				70		5.1-10.2(2-4)	7.6(3)	6	20.3(8)		None	Approximately _ of stand marked for harvest
L-4	LP	1	2.5-20.3(2-8)		10.2(4)		37		5.1-17.8(2-7)	12.7(5)	2	15.2(6)	40	None	Portion of site in LP-regeneration
M-4	LP	2	5.1-25.4(2-10)	2.5-5.1(1-2)	15.2(6)		35		10.2-30.1(4-12)	15.2(6)	14	15.2(6)		None	Portion of site in LP-regeneration
N-9	LP	2	5.1-25.4(2-10)	2.5-5.1(1-2)	15.2(6)		20	35			5	15.2(6)	30	None	Portion of site in LP-regeneration
Plant Site 1	LP	1	5.1-25.4(2-10)		17.8(7)		45		10.2-20.3(4-8)	15.2(6)	12	20.3(8)	30	None	
Plant Site 2	LP	1	5.1-25.4(2-10)		17.8(7)		45		10.2-20.3(4-8)	15.2(6)	12	20.3(8)	30	None	
Plant Site 3	LP	1	5.1-25.4(2-10)		17.8(7)		45		10.2-20.3(4-8)	15.2(6)	12	20.3(8)	30	None	

Access to the well pads would be within the same corridor as existing skid roads and other disturbed areas, except for those well pads located in the roadless area. An estimated maximum of 6.4 km (4 miles) of new road 6.7 meters (22 feet) wide would result in a habitat loss of up to 7.5 hectares (18.6 acres). Road construction activities, and the associated noise and dust, would result in temporary displacement of resident wildlife species. Dust impacts are expected to be small, owing to the proposed and required dust control activities. Indirect impacts would also result from dust produced by excavation, grading, and other earth moving activities. Temporary or short-term reductions in insect populations (resulting from dust) would reduce the available prey base for insectivores, such as bats, birds, and small mammals.

During the development phase, construction of the plant site would clear an additional 7.5 hectares (18.5 acres) of habitat. Specific habitat types impacted are discussed under each alternative.

Pipelines would generally be placed along access roads. The width of the pipeline corridors is estimated to be a maximum of 36.5 meters (120 feet), but will typically be 27 meters (90 feet) or less. Estimated acreages of lost wildlife habitat from this activity is shown in Table 4.11-1 in Section 4.11, Vegetation. An estimated maximum of 7.6 hectares (18.9 acres) of big game habitat would be lost due to pipeline and associated road construction. This loss includes 7.1 hectares (17.4 acres) of cover habitat and 0.5 hectares (1.2 acres) of forage habitat. The larger area (36.5 meters [120 feet]) required for initial construction activities staging, pipes, turnarounds, etc.) would be revegetated leaving a maximum 27.4-meter (90-foot) wide pipeline corridor and access road the only remaining areas basically unvegetated over the long term. Grasses and forbs are likely to recolonize under the pipes. Whether this regeneration would provide a discernable forage benefit to herbivores in unclear.

These pipelines would be placed above ground and their configuration and size would allow for big game movement through the area. Expansion loops would be located where heavily used big game trails intersect. Impacts to deer and elk populations and MIS, TES, and neotropical migrants populations are not anticipated.

4.12.3.2. Sumps

Each well pad site would include a clay-lined sump which would hold stormwater runoff from paved areas during the exploration, development, and utilization phases. In addition, hot water from the geothermal wells would be routed into the sump for short periods during exploration, testing, and emergency conditions during utilization. The content of the Newberry geothermal fluids is estimated at this time, therefore impacts to wildlife that can access the sumps (rodents, small mammals, birds, bats) are difficult to quantify. Because of the short duration geothermal fluids will be in the ponds, adverse impacts from ingestion of toxic levels of heavy metals that may be contained in the fluid are likely to be slight. These impacts would be the same for each action alternative. Mitigation to reduce potential impacts from the sumps is described under Alternative A and B and Additional Mitigation.

4.12.3.3. Disturbance

Road-building for the drill pad sites and the plant site would result in a temporary displacement of wildlife species. Elk and deer would use the project area less if public access to the new roads is allowed (Witmer et al., 1985).

Approximately 485.6 hectares (1,200 acres) of currently roadless areas will be roaded, with effects on big game. Road 600 has been recommended for closure at the Road 9735 junction to reduce public access and wildlife disturbance as mitigation for loss of big game cover from the Fishhook Timber Sale. Development of the geothermal project would require year-round maintenance of Roads 9735 and 600 (500 for Alternative B) to allow access to the plant site. During the initial phases of the project (exploration and development), approximately 20 cars per day would be using these roads. Once the proposed project becomes operational, human activities would be limited to visitors and the few employees working at the plant and well pads. The daily routine would allow wildlife activities, such as big game movement and bird foraging, to resume within the project area.

An osprey nest that was active in 1992 is located approximately 0.4 km (0.25 miles) north of the junction of Roads 9735 and 600. U.S. Forest Service standards identified in the Forest Plan require protection of raptor nests.

4.12.3.4. Transmission Line

The transmission line will be designed to avoid hazards to raptors. Here and in other construction areas brush and topsoil will be stockpiled, where practical, for later restoration efforts. A total of 28.1 hectares (69.5 acres) of vegetation will be cleared for the transmission line in Alternative A, and 31.6 hectares (78.2 acres) in Alternative B. Both alternatives would also feather the vegetation 7.6 meters (25 feet) on each side of the cleared area, as illustrated in Figures 2.4-17 and 2.4-22. The effects of electric and magnetic fields (EMF) for the transmission line are discussed in Section 4.14, Human Health and Safety. Magnetic field levels along the transmission line would vary from 30 milligauss (mG) directly under the line to 2 mG at the edge of the right-of-way, to less than 1 mG beyond 61 meters (200 feet) from the center of the right-of-way. Effects of EMF on wildlife are unknown. Results of current research on effects to human health are contradictory and inconclusive.

4.12.3.5. Power Plant Holding Pond

Potential adverse impacts could result during utilization from the contaminated water from the cooling tower. This water would be treated with a biocide (a chemical used to prevent algae from clogging the machinery) and released to the surface holding pond (see Section 4.14, Human Health and Safety). Levels of this biocide would be closely monitored at the plant site and would not likely occur at toxic (full strength) levels. It would be possible for excess biocide to escape into the holding pond. However, biocides break down within 24 hours after exposure to ultraviolet light and there would be a limited amount of time when the biocide would be present in the pond. Most wildlife would be blocked from access to the water storage pond by project design that requires fencing around the power plant. Small mammals (e.g., rodents, raccoons, marten) and herpetofauna, such as Pacific chorus frog, may be able to access these ponds by climbing through or over the fencing. It is not likely that MIS TES, or other species would be directly or adversely affected by operation of this project due to the lower concentrations (less than lethal levels) of biocide in the cooling water.

4.12.3.6. Deposition of Airborne Pollutants into Surface Waters

The potential for increased concentrations of metals and other elements in Paulina and East Lakes resulting from operation of the power plant has been addressed in Sections 4.3 and 4.5, Water Resources and Climate and Air Quality, respectively. Modeling of the impact of metals on the lakes has demonstrated that extremely small incremental increases of all metals can be expected from the proposed geothermal activities. Based on the modeled impacts and existing measurements of background, it can be shown, with the exception of mercury, that the sum of predicted incremental increases and existing background levels will not produce concentrations in excess of standards or threshold values. While the incremental increase of mercury is small, the existing background data are not adequate as compared to the chronic aquatic threshold values to allow comparison of the sum of impacts and background levels with the chronic aquatic threshold values.

However it must be emphasized that the predicted incremental impact of mercury after 50 years of plant operation, making extremely conservative assumptions in the modeling process, is a value four times lower than the chronic aquatic threshold value and 627 times lower than the federal drinking water standard. The background level of mercury in the Newberry lakes is less than or equal to 0.1 part per million (ppm) as measured by the US Geological Survey. The Federal drinking water standard is 0.002 ppm and the fresh chronic criteria is 0.000012 ppm. It is presently unknown whether Newberry lakes mercury levels exceed either the Federal drinking water standard or the chronic aquatic threshold.

Current (May 1994) baseline mercury levels in fish in the caldera lakes have been measured and found to contain mercury in varying levels with the concentration of mercury in some fish exceeding the U.S. Food and Drug Administration (USFDA) action level of 1.0 ppm (Table 4.12-2). The deposition modeling performed for mercury indicates that the proposed geothermal power plant could cause an increase in mercury concentrations in the lakes. Although this increase is extremely small, it may cause a slight increase in mercury concentrations in fish. Bioaccumulation of mercury in fish may elevate levels in their tissues to 0.5 ppm, a level which did not apparently affect productivity in eagles in the North Central lake states. A review of previously conducted research failed to find clear-cut indications that mercury levels equal to or lower than 0.5 ppm in fish eaten by bald eagles or osprey (another fish-eating raptor) has affected survival or productivity in these species.

Additional baseline monitoring of mercury levels in fish and in East and Paulina Lakes will be conducted. Reviews of existing research on mercury effects on eagles will continue to assess the potential significance of the slight increase of mercury in the lakes. Fish tissue sampling is under way to determine baseline levels of mercury in fish in the lakes. Preliminary results indicate that levels in fish in the size range eaten by eagles are generally below 0.5 ppm.

Table 4.12-2 Baseline Concentrations of Mercury in Fish Tissues in Newberry Lakes (May 1994)

Lake	Fish Species	Length (cm)	Weight (g)	Hg concentration (ppm)
East	Brown Trout	70.0	4100	2.09
	Atlantic Salmon	31.5	295	0.23
	Brown Trout	54.5	1750	0.42
	Rainbow Trout	40.5	845	0.18
	Rainbow Trout	30.0	335	0.34
	Brook Trout	25.5	181	0.21
	Brook Trout	27.5	255	0.38
	Tui Chub	25.5	232	0.29
	Tui Chub	28.0	334	0.12
	Tui Chub	23.5	189	0.27
	Tui Chub	21.5	155	1.42
Paulina	Blue Chub	15.0	57	< 0.05
	Blue Chub	16.5	71	< 0.05
	Blue Chub	16.0	63	< 0.05
	Brown Trout	44.5	1210	0.11
	Brown Trout	35.5	470	< 0.05
	Rainbow Trout	25.5	206	< 0.05
	Rainbow Trout	28.5	315	< 0.05
	Rainbow Trout	31.0	396	< 0.05
	Brown Trout	42.0	974	0.08

Mitigation measures will be used to reduce mercury emissions from the operating power plant. Mercury in gaseous form will be removed from the power plant emissions prior to release to the atmosphere. Removal is a two-step process involving an activated carbon adsorption system and a sulferox removal system. Together these systems operate at 98+ percent efficiency using one carbon unit. Additional units can be added, raising this efficiency level if the mercury content of the geothermal resource necessitate this additional mitigation measure. Mercury levels would be monitored at the sulferox stack and at the cooling tower to document levels of mercury emissions.

The expected life of the project is at least 50 years. At the time of decommissioning, short-term impacts would be expected to wildlife similar to those during the exploratory and development phases. Increased human activity and the noise and dust from razing the power plant and dismantling the well pad sites would temporarily displace wildlife. Over the long term, wildlife habitat will improve as the result of revegetating the previously developed sites.

4.12.3.7. TES Species

Effects on TES species have been analyzed in the Biological Evaluation on file at the Fort Rock Ranger District. No long-term impacts are anticipated from project activities to populations and habitats of the peregrine falcon, northern goshawk, or wolverine. Potential impacts which may occur to individuals of these species during all project phases are discussed below by each action alternative. Short and long term impacts to bald eagle or Pacific western big-eared bat will be avoided by implementation of mitigation measures.

4.12.4. Effects Specific to Alternative A

The area around Pad Site I-28 contains approximately 10 hectares (24.7 acres) of mature and old growth mixed conifer stands with abundant dead and downed wood and larger snags. This habitat is suitable for all MIS and neotropical migrants, providing necessary foraging, nesting, and roosting habitat. Two large raptor nests are located at the eastern end of this drill pad study site within the NSO lease area where surface occupancy is not permitted. It is unknown if these nests were active during the summer of 1993. Development on this pad site would occur on the flat area west of the cinder cone, and result in a direct and long-term loss of up to 2.3 hectares (5.7 acres) of the less suitable habitat through cutting of vegetative cover.

Impacts to wildlife could occur from drinking potentially contaminated water at well pad sumps. Under this alternative, no netting would be placed over the sumps to prevent access from drinking birds and bats, or small mammals that may climb the fences. Generally sumps will contain surface runoff, geothermal fluids and drilling fluids. Impacts from the temporary storage of hot water from the geothermal fluid cannot be quantified until the Newberry geothermal resource has been tapped and analyzed. Wildlife that come into contact with the hot fluids could be burned or killed.

Suitable habitat for MIS, TES, and neotropical migrant bird populations exists in all mixed conifer habitat located within the proposed transmission area. The most suitable habitat (featuring large-diameter trees, downed logs, and larger snags) exists primarily in T21S, R11E, Sections 15, 16 and 17; and T21S, R12E, Section 18, 19 and 20 (see Section 3.12, Wildlife, Figure 3.12-1). The transmission line right-of-way would be 30.5 meters (100 feet) wide and would result in a direct loss of up to 13.8 hectares (34 acres) of general mixed conifer habitat as well as a loss of approximately 7 hectares (17 acres) of the most suitable habitat for sensitive species.

Construction of the plant site under this Alternative (Plant Site 1) would result in the loss of 7.5 hectares (18.5 acres) of LPCC habitat. Because this habitat lacks structural (vegetative) diversity and species diversity, and therefore not considered as suitable or preferred habitat, direct and indirect adverse impacts to MIS, TES, and neotropical migrant populations are not anticipated. Deer and elk forage and travel habitat would be lost and use patterns and routes may change slightly. However, big game movement should resume in the area once the proposed plant is in operation.

Other big game impacts include road density increases and the direct and long-term loss of cover and forage habitats. Under this alternative road density would increase to an estimated 5.0 km/square km (3.1 miles/square mile), which exceeds the Forest Plan basic guideline. However, this increase would likely be mitigated through public restrictions for project security. An estimated 28.2 hectares (69.7 acres) of cover habitat and 0.1 hectares (1.3 acres) of forage habitat would be lost due to well pad development in the northern lease (SO) area. An estimated 1.9 hectares (4.7 acres) of cover habitat and 5.4 hectares (13.3 acres) of forage habitat would be lost in the southern lease area. Approximately 17.0 hectares (42 acres) of cover and 23.9 hectares (59 acres) of forage habitat would be lost due to development of the transmission line.

Depending upon actual well pad placement, suitable habitat for northern goshawk, which exists at Plant Site 1 and possibly at well pad I-28, would be lost or reduced as a result of this alternative. However, no long-term impacts to goshawk populations are anticipated. Active nest sites discovered during project activities would be protected.

TES Species. Potentially suitable day roost trees for Pacific western big-eared bat (C2) would be lost as the result of clearing for the transmission line. Bats likely use the area for foraging, roosting, and migration and may avoid the area during construction if dust levels reduce the insect prey base.

4.12.5. Effects Specific to Alternative B

Under this alternative, an additional six well pad sites (O-14, P-15, Q-15, R-21, S-21, and T-21) in the northern lease area would be available from which to choose 14 sites to be developed during exploration (Figure 4.12-1). Development of Drill Pad O-14 could result in an additional loss of up to 2.3 hectares (5.7 acres) of the deer/elk high-use area. Other impacts from this phase would be the same as those from Alternative A.

Effects on big game include road density increases and the direct and long-term loss of available cover and forage habitats. Increases in road density would likely be the same and may be somewhat less than Alternative A. Although different pad sites may be developed under this alternative, the maximum road building would be done under Alternative A.

The loss of cover and forage habitats due to well pad construction will differ from Alternative A depending upon which well pad sites are developed. The alternative six sites include 7.3 hectares (18 acres) of cover habitat and 4.8 hectares (12 acres) of forage habitat in the northern lease area. The transmission line would result in a loss of 11.1 hectares (27.5 acres) of cover habitat and 17 hectares (42 acres) of forage habitat.

Construction of Plant Site 2 would result in a loss of up to 7.5 hectares (18.5 acres) of LP and LPCC cover types. LP habitat with 10-inch dbh trees, which provide potential reproductive habitat for black-backed woodpecker (a MIS), exists within the plant area. Construction of Plant Site 3 (located south of pad site C-15) would result in a loss of up to 7.5 hectares (18.5 acres) of LP habitat. Within the 16 hectare (40-acre) siting area, the lodgepole habitat varies in tree size dbh ranging from 17.8 to 25.4 centimeters (7 to 10 inches). About 25 percent of the siting area has the larger sized snags (25.4 cm[10 inches]). This habitat is suitable for black-backed woodpecker.

Generally, LP and LPCC habitats are regarded as poor to marginal wildlife habitat due to the lack of species and vegetative diversity. Known reproductive habitat is mostly lacking within this area for other wildlife species including neotropical migrants. Direct and indirect long-term impacts to MIS and TES species is not anticipated.

Construction activities at well pad Sites A-11, B-14, and O-14 would avoid disturbing larger mixed conifer trees to the extent possible. Habitat loss within the 8- to 16-hectare (20- to 40- acre) siting areas in the SO lease area would generally be the same as for Alternative A. No construction activity would occur in the mature/old growth area at well pad Site I-28 because it is located in the NSO lease area.

To generally reduce impacts to wildlife during road and building construction activities, watering of construction areas would reduce the impact from these activities on insects and animals. The amount of vegetation removed in development of access roads and other project features would be minimized by limiting travel routes, parking areas and other site disturbance to as small an area as possible. Areas that are to be replanted, such as pipeline construction areas, could be revegetated with native or local grasses, forbs, shrubs, and trees.

Potential impacts from ingestion of potentially contaminated geothermal fluids in the sump would be mitigated by developing water sources in the vicinity, but not near well pads, to provide alternative sources of clean water to wildlife.

The transmission line area under this alternative is shown in Figure 4.11-3. Alternative B would result in a 6-hectare (14-acre) loss of mixed conifer habitat at the western end of the route. Impacts to suitable habitat within the transmission line area would be mitigated by the following means:

- Where possible in the mixed conifer habitat along the transmission line, avoid felling large live trees (greater than 51 cm [20 inches] dbh) and snags (greater than 30 cm [12 inches] dbh or greater than 25 cm [10 inches] for lodgepole) unless required for safety purposes.
- Where possible, leave stumps at least 3.6 meters (12 feet) tall to provide foraging habitat for insect gleaning birds along the transmission line right-of-way and where possible in the SO area outside of fenced areas.
- Top large trees that would be felled to prevent their falling onto transmission lines. Topped trees would continue to provide suitable foraging and nesting habitat for birds.
- "Feather" vegetation along the transmission line area both vertically and horizontally to avoid long straight edges and the appearance of a cleared swath. Revegetate with grasses and acceptable shrubs which would not impose a safety hazard to line maintenance, but would provide forage for wildlife.
- Leave larger size down woody material in the transmission line area for wildlife habitat.

Under this alternative, after decommissioning activities have been completed, the plant and well pad sites would be revegetated with native or local plant species providing food and cover for wildlife.

4.12.6. Additional Mitigation Measures

The following additional mitigation measures could be used to reduce impacts:

- Gate road into that portion of the northern lease SO area that is currently roadless to minimize disturbance to big game.
- Monitor active raptor nest sites prior to and during exploratory and development phases of the project at suitable times and frequencies to ensure that project activities are staying within any work restrictions and that nesting birds are not disturbed.
- Large trees felled to clear the transmission line area should be dropped and left to enhance wildlife habitat, where possible.

- Monitor unnetted sumps for wildlife access and deter wildlife during periods when hot water is held in sumps before the injection process. Require netting if it is determined to be needed.

4.12.7. Effects of Alternative C

If the proposed geothermal project did not proceed, then impacts to wildlife within the project area would be limited to those anticipated from other forest activities, including timber harvest already approved in the Fishhook Timber Sale.

4.13. CULTURAL RESOURCES

4.13.1. Impact Overview

Effects on cultural resources that could be associated with geothermal exploration and development are the result of surface disturbing activities in the immediate vicinity of cultural resources during the exploration or development phases. However, resources identified during field survey would be avoided by careful facilities siting.

Following identification of issues related to Native Americans raised during the scoping process, a consultation with potentially affected Native Americans was undertaken by the U.S. Forest Service. The only comment received thus far from Native Americans with regard to the proposed project is that the Tribal Council for the Confederated Tribes of the Warm Springs Reservation has expressed interest in geothermal development and views the proposed project as a pilot project for them as well. No impacts to areas of concern to Native Americans are expected to accrue from the proposed project and no mitigation is required.

4.13.2. Method of Analysis

The following criteria were used to evaluate the significance of impacts to archaeological, historic, or ethnographic resources:

- Disturbance to properties that are eligible for inclusion on the National Register of Historic Places (NRHP). (Sites whose NRHP eligibility are pending finalization of the RGPMOA are considered eligible to the NRHP for purposes of this analysis}.

- Disturbance to an area of traditional or religious importance to Native Americans.

A Class III survey of portions of the project study area was conducted in August 1993 by Far Western Anthropological Group. Results of the Class III cultural resources inventory and a review of prior cultural resources surveys and recorded site data indicate a relatively modest archaeological record for the project area. These findings support the Deschutes National Forest's findings of moderate-to-low sensitivity for cultural resources in the project area. The following assessment of potential project impacts to cultural resources is based on the known cultural resources data base for the study area. Approximately 58.1 percent of the total acreage within the study area has been subjected to cultural resources inventories which have provided meaningful data. The unsurveyed areas may contain significant unrecorded cultural resources; however, these remaining unsurveyed areas are considered to have low potential for such resources. Potential project impacts in these unsurveyed areas would require review by the appropriate permitting authority for determination of subsequent cultural resources inventory on a case-by-case basis. For purposes of the analysis presented in this EIS, the current data are sufficient to assess overall potential project impacts and specific projects for those areas previously surveyed to acceptable standards.

4.13.3. Effects Common to Alternatives A and B

There are differences in potential or expected effects between Alternatives A and B, and these are discussed below under each.

4.13.4. Effects Specific to Alternative A

4.13.4.1. Well Pads

Alternative A calls for development of 14 well pad sites in the north and south lease holdings, and construction of a gathering system for pipelines, access roads and other attendant features. Construction of such facilities would result in significant surface disturbance. There are no recorded cultural resources that would be directly impacted by the proposed well pad and gathering system facilities locations. Crew "down time" during well drilling activity could result in indirect impacts through unauthorized collection of artifacts from those surface archaeological sites in close proximity to well pad or gathering system facilities.

4.13.4.2. Power Plant

Alternative A includes one power plant location (Plant Site 1). Prior cultural resources survey data indicates that this location is devoid of visible cultural resources.

4.13.4.3. Transmission Line Area and Access Road

The proposed transmission line route for Alternative A has been subjected to cultural resources inventories over approximately 6.7 km (4.2 miles) of its 13.1-km (8.2-mile) length. The actual construction right-of-way would be 30.4 meters (100 feet) wide. Construction and maintenance activities associated with the transmission line have the potential to directly impact significant cultural resources. As currently configured the route has the potential to cross the following sites considered by Far Western Anthropological Group to be eligible to the NRHP. However, final eligibility determinations await agency review and SHPO concurrence:

- 150-FRD-82-P: small lithic scatter in severely disturbed context
- 174-FRD-82-H: logging railroad grade segment (approximately 366 meters [1,200 feet] long) and associated berm
- 289-FRD-85: small lithic scatter
- 1216-FRD-92-H (Segment 7): Shevlin-Hixon logging railroad segment. This segment is described as an approximately 1.6 km (1 mile) grade with a few badly deteriorated ties; site has minimum integrity.
- 775-FRD-89-P: small lithic scatter
- 1216-FRD-92-H (Segment 1): Shevlin-Hixon logging railroad grade segment (approximately 731.5 meters [2,400 feet] long) with several dozen degraded railroad ties
- 1124-FRD-91: small, single episode trash dump

Sites which are considered eligible to the NRHP and, although in close proximity, appear to be at least 152 meters (500 feet) from the proposed transmission line route include:

- 1216-FRD-92-H (Segment 23): Shevlin-Hixon logging railroad grade segment (approximately 610 meters [2000 feet] long)

- 1216-FRD-92-H/8-6-93 (Segment 1): Shevlin-Hixon logging railroad grade segment (approximately 732 meters [2400 feet] long) with several dozen degraded railroad ties
- 1216-FRD-92-H/8-6-93 (Segment 2): Shevlin-Hixon logging railroad grade segment (approximately 113 meters [370 feet] long) with several faint railroad ties and four paint cans

The proposed access road for the transmission line would utilize Road 9735 from the west end of the transmission line area to Spur Road 500 where it would leave Spur Road 500 and parallel the proposed transmission line area and connect to Road 600. This would require approximately 1.6 km (1 mile) of new road construction and widening/upgrading of Spurs 500 and 600. Construction and maintenance activities associated with the new construction/upgrades have the potential to directly impact significant cultural resources. As currently configured the route has the potential to cross (from east to west) the following sites considered to be eligible to the NRHP:

- 1216-FRD-92-H (Segment 7): Shevlin-Hixon railroad grade segment. This segment is described as an approximately 1.6 km (1 mile) grade with a few badly deteriorated ties; site has minimum integrity.

Sites which are considered eligible to the NRHP and appear to be located within 152 meters (500 feet) of Road 9735, but are not intersected by it, include (from east to west):

- 150-FRD-82-P: small lithic scatter in severely disturbed context
- 174-FRD-82-H: logging railroad grade segment (approximately 366 meters [1,200 feet] long) and associated berm
- 775-FRD-89-P: small lithic scatter
- 1216-FRD-92-H/8-6-93 (Segment 1): Shevlin-Hixon logging railroad grade segment (approximately 731.5 meters [2,400 feet] long) with several dozen degraded railroad ties
- 1124-FRD-91: small, single episode trash dump
- 1216-FRD-92-H/8-6-93 (Segment 2): Shevlin-Hixon logging railroad grade segment (approximately 113 meters [370 feet] long) with several faint railroad ties and four paint cans

Construction of the transmission line within the proposed corridor has the potential to disturb five significant sites (150-FRD-82-P, 174-FRD-82-H, 289-FRD-85, 1216-FRD-92-H, 775-FRD-89-P). Each of these sites is a discrete entity that can be avoided by minor north-south shifts (no more than 23 meters [75 feet]), placement of pole structures off-site, stringing line to cross sites, and routing of access routes to poles away from sites. Monitoring of transmission line construction near significant sites would be required.

Utilization of Road 9735 with modification/upgrades at Spurs 500 and 600 and new construction joining the two spurs has the potential to affect Site 1216-FRD-92-H7). This segment of the project area is currently transected by Road 9735; therefore no new impacts would accrue by use of this segment of the road. No mitigation is necessary.

No known cultural resources would be impacted by project-related effects as described above with regard to well pad locations, gathering systems and plant location. However, if previously undocumented sites are discovered during construction, activities would be halted until the resources are examined by a professional archaeologist and direction is given on how to proceed.

If significant cultural resources are encountered relocation of facilities would be considered in order to mitigate possible project effects to the resource.

4.13.5. Effects Specific to Alternative B

4.13.5.1. Well Pads

Alternative B includes identification of 20 potential well pad sites in the north and south lease holdings of which 14 would be used, and construction of a gathering system that could include up to 14.6 km (9.1 miles) of corridor for pipelines, access roads and other attendant features. Construction of such facilities would result in significant surface disturbance. There are no recorded cultural resources that would be directly impacted by the proposed well pad and gathering system facilities locations. Crew "down time" during well drilling activity could result in indirect impacts through unauthorized collection of artifacts from those surface archaeological sites in close proximity to well pad, or gathering system facilities.

Alternative B has one site in, and one site immediately adjacent to, the northern lease which are situated in close proximity (76 meters [250 feet]) to well pad locations or the gathering system corridor. These two NRHP eligible sites are:

- 1280-FRD-93-P: lithic scatter containing 75 obsidian flakes, no formed tools recorded
- 1281-FRD-93-P: lithic scatter containing 50 obsidian flakes and three biface fragments

Potential impacts to the two sites near the well pads/gathering system would be mitigated by avoidance.

4.13.5.2. Power Plant

Alternative B includes Power Plant Site 1 (from Alternative A) and two additional possible power plant locations (Plant Sites 2 and 3 [Figure 2.4-19]). Prior cultural resources survey data indicate all three locations are devoid of visible cultural resources.

4.13.5.3. Transmission Line

The Alternative B transmission line route has been subjected to cultural resources inventories over approximately 9 km (5.6 miles) of its 13.1-km (8.2-mile) length. The actual construction right-of-way (ROW) would be 23 meters (75 feet) wide. Construction and maintenance activities associated with the transmission line have the potential to directly impact significant cultural resources. As currently configured the route has the potential to cross (from east to west) the following sites considered to be eligible to the NRHP:

- 150-FRD-82-P: small lithic scatter in severely disturbed context
- 174-FRD-82-H: logging railroad grade segment (approximately 366 meters [1200 feet] long) and associated berm
- 1216-FRD-92-H/8-6-93 (Segment 1): Shevlin-Hixon logging railroad grade segment (approximately 2400 feet long) with several dozen degraded railroad ties
- 1216-FRD-92-H/8-6-93 (Segment 3): Shevlin-Hixon logging railroad grade segment (approximately 67 meters [220 feet] long), no associated artifacts
- 1216-FRD-92-H/8-6-93 (Segment 4): Shevlin-Hixon logging railroad grade that is currently the base for a spur to Road 052

Each of the sites near the Alternative B transmission line area is a discrete entity that could be avoided by minor north-south shifts (no more than 23 meters [75 feet]), placement of pole structures off-site, stringing line to cross sites, and routing of access routes to poles away from sites. Monitoring of transmission line construction near significant sites would be required.

No known cultural resources would be impacted by project-related effects as described above with regard to well pad locations, gathering systems and plant location. However, if previously undocumented sites are discovered during construction, activities would be halted until the resources are examined by a professional archaeologist and direction is given on how to proceed. If significant cultural resources are encountered, relocation of facilities would be considered in order to mitigate possible project effects to the resource.

4.13.6. Additional Mitigation Measures that Could be Applied to Alternatives A or B

In order to reduce the potential for nearby significant sites to be impacted by unauthorized collection by personnel associated with the proposed project, it is recommended that a crew education briefing program be instituted. During each phase of the proposed project — exploration, development, utilization and decommissioning — crews associated with these phases would be briefed by an agency archaeologist, or designated representative, regarding the nature of nearby cultural resources and the legal requirements precluding collection/disturbance at these sites. Secondarily, crews would be briefed on agency notification procedures should previously undiscovered resources be exposed during surface disturbing activities.

4.13.7. Effects of Alternative C

Alternative C would result in no new impacts to significant cultural resources associated with any of the project components.

4.14. HUMAN HEALTH AND SAFETY

4.14.1. Impact Overview

Potential effects on human health and safety from geothermal development can be described in five categories of potential effects from hazardous materials, fire, well blowouts, air pollution, and electric and magnetic fields. The issue of potential contamination of shallow groundwater used for drinking water is addressed in Section 4.3, Water Resources. During exploration, development, utilization, and decommissioning, hazardous materials would be transported in and out of the project area, stored, used, and disposed. Improper handling of these materials could lead to human exposure and consequent effects on health and safety. Exposure could result from release of material as a result of traffic accidents involving vehicles transporting materials as well as accidental spills and releases on site. Likelihood of fire would be increased during all phases of the project because it would bring additional people, materials, machines, and processes into the project area. Fires which start on-site could spread off-site. Also, fires which start off-site could threaten the people and facilities in the project area. Additionally, in the event of fire, stored hazardous and volatile materials could be released. However, having a facility that is staffed and operational around the clock could result in earlier detection and response to fires in the area.

During exploration, and to a lesser extent during utilization, well blowouts could occur with resulting uncontrolled discharge of well fluids and/or gases that could affect human health and safety. Air pollution, particularly hydrogen sulfide (H_2S) emissions, is associated with geothermal exploration, development, and utilization and could affect human health and safety, primarily project workers. The utilization phase would include the transmission of power along a 115-kV transmission line. This would create electric and magnetic fields along the transmission corridor. These fields could affect human health and safety.

4.14.2. Method of Analysis

The method of analysis for public health and safety effects was to identify scenarios which could affect public health and safety and then to characterize the probability of occurrence and severity of consequence of the scenario. Scenarios were identified for each of the five categories of effects discussed in Section 4.14.1, above. Scenarios associated with hazardous materials for the exploration, development, and utilization phases include accidents during transportation, storage, and disposal of hazardous materials. Fire scenarios include on-site fires, on-site fires moving off-site, off-site fires, off-site fires moving on-site. Occurrence of blowouts during exploration and utilization phases were analyzed. Effects from air pollutants and electric and magnetic fields were also analyzed.

Scenario probabilities were characterized as low, medium, or high. Low probability was assigned to scenarios deemed unlikely to occur during the project lifetime; medium probability to scenarios which may occur during the project lifetime; and high probability to scenarios which are likely to occur at least once during the project lifetime. Severity of consequence for scenarios was also characterized as low, medium, or high. Where possible, the characterizations were based upon quantitative analysis.

This analysis included reviews of relevant state and Federal guidelines and regulations for public health and safety, internal BPA guidelines on effects from electric and magnetic fields, and discussions with CEE describing expected project processes and operations. Data sources included traffic volume and accident statistics from the National Safety Council, fire history data from U.S. Forest Service Fort Rock District, and well blowout data for offshore oil wells from a report by Gulf Oil's Houston Technical Services Center (1981) entitled "Analysis of Accidents in Offshore Operations Where Hydrocarbons Were Lost." Oil well data are referenced because no specific data are available for geothermal wells.

4.14.3. Effects Common to Alternatives A and B

With respect to human health and safety, Alternatives A and B would be treated the same since they involve the same amounts of hazardous materials and exploration, development, and utilization activities. While some differences in probabilities of occurrence of incidents between the two alternatives may exist if exact locations for well pads, sumps, power plant, transmission lines, and pipelines were known, the magnitude of these differences, if any, cannot be estimated, and is expected to be small.

Certain actions would be taken to generally minimize the effect of the project on human health and safety. The plant operating area perimeter would be bermed and the plant site secured with a chain link fence to prevent access from fauna and recreationists in the local area. A backup diesel generator would be provided to supply emergency power when the unit is shut down. Restricted (hard hat) areas would be identified throughout the project site. All drilling operations would be conducted in compliance with the GRO Orders. Upon completion of temperature gradient and core holes, the wellhead gate valve would be chained and locked to prevent unauthorized access. Wellhead cellars would be covered with heavy duty timber and nailed shut. The main access roads and local spur roads to the production well pads would be plowed in winter to remove snow as necessary to provide access to operating areas.

4.14.3.1. Hazardous Materials

The term "hazardous materials" refers to substances which, if released in an uncontrolled manner, can be harmful to people, animals, property, and/or the environment (Planning Guide and Checklist for Hazardous Materials Contingency Plans, Federal Emergency Management Agency, July 1981). At any time, a variety of chemicals would be used and stored on the site. Some of these chemicals may be deemed "hazardous." Appendix H lists the chemicals that are anticipated to be used during drilling and utilization, with estimated quantities, consumption rates, and delivery schedules. A hazardous materials plan would be prepared and approved, and all materials would be handled and disposed in accordance with this plan and state or Federal regulations governing those materials. In addition, materials would be handled and disposed of in accordance with information presented on Material Safety Data Sheets (MSDSs; these are not presented in this document, but are available for viewing in the project files or upon request).

Exploration and Development. Table 4.14-1 lists materials expected to be used during the exploration phase along with their degree of estimated hazard. The severity of consequence, based on the degree of estimated hazard, for each material is defined below:

- **Low**: This characterizes materials that have National Fire Protection Association (NFPA) degrees of hazard of "0" or "1"; are unlikely to enter a drinking water supply; or involve small (<208 liters [55 gallons]) quantities of material. They involve materials stored in bermed areas.

- **Medium**: This characterizes materials with NFPA degrees of "2" or "3"; are likely to enter a drinking water supply via groundwater infiltration or surface runoff; or involve medium quantities (208 to 3,785 liters [55 to 1,000 gallons]) of material. They involve materials stored in unbermed areas disjunct from human activity.

- **High**: This characterizes materials with NFPA degrees of "4"; are likely to enter a drinking water supply via direct contact; or involve large quantities (>3,785 liters [1,000 gallons]) of material. They involve materials stored in unbermed areas near human activity.

The majority of the compounds listed in Table 4.14-1 have a degree of health hazard of "0" or "1" and are thus considered to have a low severity of consequence if released. Caustic soda, scale inhibitor, ammonium alcohol sulfate, and corrosion inhibitor have a degree of health hazard of "2" or "3" and are thus considered to have a medium severity of consequence if released. Caustic soda and scale inhibitor are categorized as acids/bases/oxidizers; ammonium alcohol sulfate is a potential carcinogen/teratogen; and corrosion inhibitor is categorized as a solvent. Additional information on how these compounds are used is presented in Appendix H.

Ammonium alcohol sulfate is characterized as having a medium severity of consequence with respect to flammability (degree of estimated hazard = 3), whereas all other compounds are characterized as having a low severity of consequence with respect to flammability. The majority of the materials are incompatible with either acid, oxidizers or heat, and some are incompatible with more specific compounds. However, based upon the NFPA's degree of reactivity, all compounds are characterized as having low severity of consequence with respect to reactivity.

Using the truck delivery schedule from Table H-1 in Appendix H for those compounds denoted as hazardous, there would be an estimated 16 deliveries of hazardous materials per well, assuming separate deliveries for each material. If separate deliveries are assumed for each well, then there would be an estimated 224 deliveries of hazardous materials for the exploration and development phases of the project which could last over a period of several years (until the year 2000). Disposal of hazardous materials would generate 14 trips during the exploration phase. These assumptions provide an estimate of trips that should be at least as great as the actual number of trips. Table 4.14-2 summarizes the number of trucks and estimates quantities of hazardous materials being transported and compares them to the baseline figures from Section 3.14.2.1.

Table 4.14-1
Potential Drilling Materials and Their Properties
(Based Upon Transportation and Material Safety Data Sheet Information)

Material**	Area of Use	Storage Quantity	Storage Structure	Hazardous Ingredients	Degree of Estimated Hazard*			Incompatibility
					Health Hazard	Flammability	Reactivity	
Caustic soda/ Sodium hydroxide	Drilling fluid compound - alkalinity control	450 lb bimonthly; per well; 60 days per well	50-lb sacks; inside earth berms	sodium hydroxide	3	0	1	Acid; water; organochlorine solvents; nitro and nitrose compounds; organic peroxides; metals (Al, Zn, Sn) and their alloys
Corrosion inhibitors (Conqor 404/phosphate ester salt)	Drilling fluid compound - corrosion inhibitor	Unknown at this time (unknown)	5 or 55-gal drums; inside earth berms	None	1	1	0 (biodegradable)	Oxidizer
Cottonseed hulls	Drilling fluid compound - lost circulation	Unknown	50 to 100-lb bags	cotton dust (raw)	1	1	0	Heat
Defoamer (Defoam-X)	Drilling fluid compound - defoamant	Unknown	5 or 55-gal drums	None	1	0	0	Heat
Lime/Calcium hydroxide	Drilling fluid compound - calcium source	1,450 lb bimonthly; per well; 60 days per well	50-lb sacks; inside earth berms	calcium hydroxide	0	0	0	Acid; CO_2
Lubricant (Lube-167)	Drilling fluid compound - lubricant	Unknown	55-gal drums; inside earth berms	glycol ethers generic	1	1	0	Oxidizer
Sodium Montmorillonite-bentonite (M-I Gel)	Drilling fluid compound - viscosifier	169,000 lb bimonthly; per well; 60 days per well	100-lb sacks; inside earth berms	silica (quartz)	1	0	0	—
Nut Plug 0 - All grades (ground nut shells)	Drilling fluid compound - lost circulation	Unkown	50-lb bags	None	0	1	-	Oxidizer
Cellulose (Polypac)	Drilling fluid compound - fluid loss reducer	Unknown	50-lb bags	None	0	1	0	—

Table 4.14-1 (Continued)
Potential Drilling Materials and Their Properties
(Based Upon Transportation and Material Safety Data Sheet Information)

Material**	Area of Use	Storage Quantity	Storage Structure	Hazardous Ingredients	Degree of Estimated Hazard*			Incompatibility
					Health Hazard	Flamma-bility	Reactivity	
Liquid anionic polyelectrolyte (Poly-Plus liquid)	Drilling fluid compound - polymer	Unknown	5-gal pails; inside earth berms	Ethoxylated octyl phenol; paraffinic/nap hthenic solvent	1	1	0 (biodegradable)	Oxidizer
Salt/sodium chloride	Drilling fluid compound - densifier	86,500 lb bimonthly; per well; 60 days per well	100-lb sacks; inside earth berms	None	0	0	0	Acid
Scale Inhibitor (SI-1000/organic phosphate blend)	Drilling fluid compound - scale inhibitor	110 gal bimonthly; per well; 60 days per well	55-gal drums; inside earth berms	Ethylene glycol	2	1	0	Heat
Sodium bicarbonate	Drilling fluid compound	600 lb bimonthly; per well; 60 days per well	100-lb sacks; inside earth berms	None	1	0	0	Reacts violently with Na, K, NH_4, H_2, PO_4
Ammonium alcohol sulfate (Sulfotex PAI/Sulfated C10-12 alcohol ethoxylate, ammonium salt-aqueous solution)		220 gal bimonthly; per well; 60 days per well	55-gal drums; inside earth berms	Ammonium deceth/Laureth sulfate; isopropyl alcohol; glycol ether; ethylene oxide; acetaldehyde; 1-4-dioxane	3	3	0	Heat; oxidizers
Dispersant (Tannathin/lignite-Leonardite)	Drilling fluid compound - dispersant	2,350 lb bimonthly; per well; 60 days per well	50-lb sacks; inside earth berms	Lignite (coal dust); silica	1	1	0 (biodegradable)	Heat
Corrosion inhibitor (Unisteam/fatty acid ester/polyamine complex)	Corrosion inhibitor	Unknown	55-gal drums; inside earth berms	Diethylene-triamine	3	1	0	Acid

Sources: "Estimated Chemical and Solid Waste handling and Storage Requirements" and "Example Transportation and Material Safety Data Sheets." Provided by M-I Drilling Fluids Company

* Key: See following page

**Included in parentheses is one example of a common brand name product used for this area of use. This example is given in order to supply general information about the material in the form of a T&MSDS. The inclusion of this example does not imply that the proposed project would use this product.

Table 4.14-1 (Continued)
Degree of Estimated Hazard

HEALTH HAZARD - Type of Possible Injury

4	A few whiffs of the vapor could cause death; or the vapor or liquid could be fatal on penetrating the fire fighter's normal full protective clothing, which is designed for resistance to heat.
3	Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing should be provided. No skin surface should be exposed.
2	Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
1	Materials only slightly hazardous to health.
0	Materials which, on exposure under fire conditions, would offer no health hazard beyond that of normal combustible material.

FLAMMABILITY - Susceptibility of Materials to Burning

4	Very flammable gases, very volatile flammable liquids, and materials that, in the form of dusts or mists, readily form explosive mixtures when dispersed in air.
3	Liquids ignitable under almost all normal temperature conditions, solids that burn rapidly, and any material that ignites spontaneously at normal temperatures in air.
2	Liquids that must be moderately heated before ignition will occur, and solids that readily give off flammable vapors.
1	Materials that must be preheated before ignition can occur.
0	Materials that will not burn.

REACTIVITY - Susceptibility to Release of Energy

4	Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures.
3	Materials which in themselves are capable of detonation or of explosive decomposition or of explosive reaction, but which require a strong initiating source or which must be heated under confinement before initiation.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate.
1	Materials which in themselves are normally stable but which may become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.
0	Materials which are normally stable even under fire exposure conditions and which are not reactive with water.

Source: Identification System: Fire Hazards of Materials 1975,
National Fire Protection Association, NFPA
Publication No. 704, 23 pp.

Table 4.14-2 Yearly Transportation of Hazardous Materials

Phase	Number of Trucks [Percentage of Baseline Value]	Amount of Hazardous Materials: Kg (Pounds) [Percentage of Baseline]	Liters (Gallons) [Percentage of Baseline]	Cubic Meters (Cubic Feet) [Percentage of Baseline]
Baseline[1]	4,490	23,808,931 (52,488,825)	26,156,412 (6,910,545)	24,901 (879,285)
Exploration and Development				
Drilling	224 (5%)[2]	2,858 (6,300) [<0.1%]	3,601,173 (687,232) [10%]	—
Disposal	14 (0.3%)	—	25,435 (6,720) [0.1%]	
Total	238 (5%)	2,858 (6,300) [<0.1%]	2,626,608 (693,952) [10%]	—
Utilization				
Operation	69 (1.5%)	—	132,580 (35,025) [0.5%]	326 (11,520) [1%]
Production	24 (0.5%)	136 (300) [<0.01%]	20,242 (5,348) [<0.1%]	—
Sulferox	13 (0.3%)	—	378,519 (10,005) [0.1%]	—
Disposal	4 (<0.1%)	—	2,725 (720) [<0.1%]	—
Total	110 (2%)	136 (300) [<0.01%]	193,311 (51,073) [1%]	326 (11,520) [1%]

1 Baseline values are from Table 3.14-2.
2 Numbers in brackets are percentages of baseline values.

Data from the National Safety Council for 1991 shows 740,000 medium/heavy trucks involved in accidents and 155,990,940,000 km (96,949,000,000) miles travelled by combination trucks. Assuming one truck per accident and that medium/heavy trucks correspond to combination trucks, this provides an estimated accident rate of 7.6 truck accidents per 1,609,000 truck kilometers (1,000,000 truck miles), which for the purposes of this analysis would be rounded up to 10 accidents per 1,609,000 vehicle kilometers (1,000,000 vehicle miles) for trucks. Assuming an average of 161 km (100 miles) per trip for delivery or disposal of hazardous materials, the exploration phase would generate 38,294 vehicle km (23,800 vehicle miles) of transportation of hazardous materials (36,042 km [22,400 miles] for delivery and 2,253 vehicle km [1,400 miles] for disposal). Applying the accident rate of 10 accidents per 1,609,000 vehicle km (1,000,000 vehicle miles) provides an estimate of 0.238 accidents involving transportation of hazardous materials during the exploration phase of the project.

All hazardous material storage would be contained on the drilling sites. Hazardous materials would be stored in areas with secondary containment features. Drums and dry paletted chemicals would be set inside earth berms. Liquid collected within the berms would be channeled to the clay-lined drilling sumps. All chemical injection systems installed at the well pads would be placed in a concrete or asphalt bermed area to contain potential spills. Based upon the proposed containment methods and lack of drinking water supplies in the immediate area, it is unlikely that uncontrolled release from the storage of hazardous materials would occur during the exploration and development phases.

All hazardous wastes would be disposed off-site. These wastes would include used engine, gear, and hydraulic oil. Drilling wastes (cuttings with used drilling mud) are unique to each site and potentially to each drill pad and cannot be compared to other geothermal sites (USEPA 1983a; USEPA 1983b; Weres 1988). Therefore the constituents, level of hazard, and severity of consequence cannot be characterized until drilling is performed. If drilling wastes are found to be nonhazardous they would be disposed on-site and the disposal site revegetated if appropriate, otherwise they would be disposed at approved facilities off-site. Since all hazardous wastes would be disposed off-site, the probability of release may be equated with that associated with the transport of hazardous materials during exploration, which has been estimated as 0.238 accidents.

Utilization Hazardous materials expected to be used during the utilization phase of the project are listed in Tables H-2, H-3, H-4, and H-5 in Appenix H. Their properties and potential risks are summarized in Table 4.14-3 and are discussed in an assessment of potential adverse impacts of geothermal developments in the Deschutes National Forest (Galliano 1986).

Table 4.14-3 Drilling Operation Hazardous Materials and Their Potential Impacts

Material	Hazard and Estimated Degree	Description
Caustic Soda (sodium hydroxide)	Health Hazard: 3	Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing should be provided. No skin surface should be exposed.
Scale inhibitor	Health Hazard: 2	Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
Ammonium alcohol sulfate	Health Hazard: 3	Health Hazard: Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing should be provided. No skin surface should be exposed.
	Flammability: 3	Flammability: Liquids ignitable under almost all normal temperature conditions, solids that burn rapidly, and any material that ignites spontaneously at normal temperatures in air.
Corrosion inhibitor	Health Hazard: 3	Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing should be provided. No skin surface should be exposed.

Source of Description: "Identification System: Fire Hazards of Materials 1975." National Fire Protection Association, NFPA Publication No. 704, 23 pp.

Hazardous materials proposed to be used during plant operations and production, if spilled, would have varying effects. Vapors released during a spill would pose the greatest risk. The biggest risk would be to project workers. Vapor risks would require a large quantity of release to affect the public. The severity of consequence for these exposures would depend upon the quantity and nature of the vapors released, and weather conditions at the time, but could be potentially high if there is little or no wind. The only materials with hazardous gases that will be used by the project in significant quantities are petroleum products like diesel fuel. Appendix H indicates that diesel fuel will be delivered in the greatest quantity (15,000 liters [4000 gallons]) and with the greatest frequency (6 times per year) of the materials that have hazardous gases. Gas emissions from a 15,000-liter (4000-gallon) spill of diesel fuel are not expected to pose a significant hazard to campers and visitors.

Other materials which would be used for plant maintenance include diesel fuel, oils (engine, gear, hydraulic, compressor), thread dope, grease, and anti-freeze (Table H-2). These materials, if spilled and uncontained, could affect water quality through surface runoff or groundwater infiltration. These materials are characterized as having medium severity of consequence.

Materials proposed for the H_2S abatement system are potentially hazardous to workers. These are listed in Table H-4 in Appendix H. These materials are potential irritants (dermal, ingestion) and are characterized as having medium severity of consequence. Chemicals proposed for use in the laboratory are listed in Table H-5 in Appendix H.

Assuming an average of 161 km (100 miles) per trip for delivery of hazardous materials and 12 trips per year, the utilization phase would generate 1,900 vehicle km (1,200 vehicle miles) of transportation of hazardous materials per year. Applying the conservative accident rate of 10 accidents per 1,690,000 vehicle km (1,000,000 vehicle miles) provides an estimate of 0.012 accidents per year involving transportation of hazardous materials during the utilization phase of the project, or approximately one accident during a 50-year project life.

Hazardous materials would be stored in areas with secondary containment features. Many of the chemicals proposed to be used for plant maintenance (excluding fuels, oils and compressed gases) would be stored in relatively small quantities. Fuels are to be stored in above-ground 15,000-liter (4,000-gallon) steel tanks situated in a concrete firewall/containment pad. The pad would have 1.5 times the storage capacity of the largest tank. Polymaleic acid solution for production would be stored in insulated 22,710-liter (6000-gallon) tanks housed in a centrally located building in the field gathering system. Seaco 3530C totes would be stored in heated buildings and are re-usable. All chemicals for the H_2S abatement system would be stored in fiberglass bulk tanks inside a coated, concrete basin. The bulk storage tanks would either be enclosed in a building or heat-traced. All chemical injection systems installed at the well pads would be placed in a concrete or asphalt bermed area to contain potential spills. Based upon the amounts to be stored, the containment methods, the lack of drinking water supplies in the immediate area, and OSHA safety requirements the probability of uncontrolled release from storage is low.

Used oil removal would be combined with used oil steam from Plant Maintenance and disposed off-site. Empty oil drums are considered nonhazardous in Oregon (CEE 1993a). If approved by the Oregon Department of Environmental Quality, all other hazardous materials would be disposed in the injection wells with the excess geothermal fluids (brine). The injected chemicals would degrade, with high wellbore temperatures, into nonhazardous components and become part of the reservoir. The degradation products are given in Appendix H. It has been concluded that disposal methods other than reinjection appear to pose a higher risk of pollution to the local environment (Galliano 1986). Handling of the materials according to Federal and state regulations would be required and would reduce the risk to the public. Probability of release during disposal is also low.

Other mitigation measures to be used include removable winter enclosures to provide clear access to certain equipment, heat tracing equipment for all piping that has the potential to freeze, and pipeline thermal expansion for all pipelines.

4.14.3.2. Fire

Many of the above discussed materials are potential fire hazards, either individually or in combination with an incompatible material or circumstance. The fire hazards of individual chemicals used in the drilling pad areas, for plant maintenance, in the field gathering system, and in the laboratory are discussed in detail in "Hazardous and Non-Hazardous Materials Required for or Produced by a 30 MW Geothermal Plant" (CEE 1993a). Potential flammable/combustible chemicals which would be used for the project are summarized in Table 4.14-4.

Table 4.14-4 Potential Flammable/Combustible Chemicals Which Would Be Used in the Proposed Project

Area Of Use	Materials	Comments
Drilling Operations	Oils; fuels; ammonium alcohol sulfate	
Plant Maintenance	Oils; fuels; solvents; compressed gases; starting fluid/others	
Field Gathering System	Corrosion inhibitor; silica inhibitor; Polymaleic acid	Main constituent is isopropanol which is combustible
Laboratory	Several	Stored in small quantities

Additional fire hazards exist from processes used in the exploration, development, and utilization phases. These include drilling, use of power tools, plant operation, and piping of hot geothermal fluids. Also, the presence of people in a forested area, independent of project activity, increases the risk of human-caused fire.

The severity of consequence of any fire cannot be predicted. As discussed in Section 3.14.2, most fires in the region between 1970 and 1992 burned less than 0.4 hectare (1 acre). However, the possibility always exists that a much larger fire could result from any incident. For example, in 1988 the Paulina fire burned 5,261 hectares (13,000 acres).

Probabilities for fire due to plant processes cannot be provided. Measures would be taken to minimize the probabilities. Spark arresters would be used on all potential spark-emitting equipment. The chemicals which pose a fire hazard and are associated with plant maintenance and the laboratory would be stored in the main plant building which would be constructed of non-flammable, flame retardant material (i.e., a rigid, steel-frame structure with steel panel walls and steel roof). In addition, the proposed facility would be equipped with a comprehensive fire protection system. This would include detection, alarm, and suppression and extinguishing capabilities. "Appropriate detection systems for each hazard would be provided to detect abnormal conditions," (CEE 1992b). These detection systems would automatically discharge the extinguishing agent and sound the alarm. The specific detection systems are not detailed. In general, most components of the proposed project facilities would be made of fire-retardant materials. The cooling towers, however, would include wood construction.

The type of suppression and extinguishing systems to be used in the various areas of the facility are outlined in Table 4.14-5. Fire water pumps and a 378,500-liter (100,000-gallon) fire water tank are proposed to maintain line pressure and water supply. These would also supply indoor and outdoor fire hydrants and fire hose houses which would be located throughout the plant. Also, portable hand-held fire extinguishers would be provided in conspicuous locations within various building sections.

There would be fire breaks around the well pads and the power plant. There would be a 15-meter (50-foot) fire break around the plant site perimeter. The power plant area would be cleared of vegetation and paved. The production and injection pipelines and the transmission lines would have cleared corridors. These would help protect the surrounding area from fires which originate on-site, and help protect the facilities from fires which originate off-site. The Plan of Operations incorporates the general fire protection and suppression provisions of the U.S. Forest Service Region 6 Fire Protection Plan. Fire inspection by U.S. Forest Service personnel would be conducted during the fire season. Fire-fighting equipment and safeguards would be available to assist the U.S. Forest Service in detecting new fires and helping to suppress fire in the area. A fire evacuation and emergency plan would be approved, in place, and tested on a regular basis. As stated in the impact overview, having a facility that is staffed and operational 24 hours a day could result in earlier detection and response to fires.

Table 4.14-5 Proposed Suppression/Extinguishing Systems

System	Area
Fixed automatic water spray deluge system	Cooling tower; transformers; turbine-generator and lube oil unit
Automatic wet-pipe sprinklers and total flooding Halon suppression system	Control room; switch gear; motor control center; and chemical laboratory
Automatic wet-pipe sprinklers	Administrative building; liquid redox system; and warehouse and shop buildings

The probability of fire due to increased human presence can be roughly estimated based on available information. The fire database from the U.S. Forest Service shows that in 1992, 25 nonlightning fires occurred in the Fort Rock District. Table 3.9-2 shows a total of 337,175 visitor days at the NNVM. Because the NNVM occupies only a portion of the Fort Rock District, using the NNVM visitor days clearly provides an under-estimate of visitor use of the Fort Rock District and therefore potential for human-caused fires as a result of the project-associated personnel. These figures can be used to approximate an upper bound of 0.000074 fires per visitor day which can be applied to the project personnel numbers. This is therefore a very conservative estimate. Taking the data from Table 4.15-1 for number of workers per quarter, assuming 91.25 workdays per quarter, and equating workdays with visitor days yields the following estimates for expected number of fires due to increased human presence:

1995	1.9 fires
1996	3.9 fires
1997	2.1 fires
1998 and on	0.17 fires per year or ~8 fires for a 50-year project life.

4.14.3.3. Blowouts

A well blowout is defined as "an unexpected and sudden escape of steam and/or hot water from a geothermal well." A blowout occurs when the encountered formation pressures exceed the pressure exerted by the column of drilling mud. This allows the geothermal fluids to blow out the well hole. The effect of a blowout would include air pollution from the escaping steam and gases, noise, damage to vegetation, and risks to wildlife and workers. The specific consequences of a blowout cannot be predicted (because it depends on the nature and duration of the event), but a blowout could potentially have a high severity of consequence.

Blowouts could occur during the drilling in the exploration phase, or during production in the utilization phase. Very few blowouts have occurred in geothermal wells. Blowouts have occurred at The Geysers, in northern California, and were controlled by injecting cement slurry into the casing. The primary defenses against blowouts are siting wells to avoid landslides, maintaining proper mud density, monitoring formation pressures, use of a blowout preventer to close off the well, and a properly selected casing program to eliminate shallow weak zones. Blowout prevention equipment would be installed during drilling. The power plant facility would have an emergency shut-in program in the distributed control system, which would allow the operator to shut-in a single well or all wells simultaneously in an emergency situation.

With over 2,700 MW of installed geothermal generating capacity in the U.S. as of the end of 1990 (U.S. Department of Energy 1991a) and over 2,000 wells drilled, only eight blowouts can be readily cited (Anderson 1994):

Location	Number of Blowouts
The Geysers, California	4
Surprise Valley, California	1
Cove Fort, Utah	1
Hawaii	1
Stillwater, Nevada	1

Two of the blowouts at The Geysers were caused by landslides that sheared off the well head. These events occurred before directional drilling technology made it possible to site well pads on more stable ground. The Surprise Valley blowout occurred in 1959 during drilling without standard blowout prevention equipment. The blowouts at Surprise Valley, Cove Fort, and Stillwater occurred when pressurized reservoirs were encountered at shallow depth. Past drilling in the project area indicates the geothermal reservoir is at least several thousand feet below the surface (see section 3.4.3). Therefore, the risk of a blowout is considered low. Geothermal well blowouts are typically less frequent than for oil wells.

4.14.3.4. Air Pollution

The primary potential pollutant which may effect human health and safety is H_2S. Its characteristic "rotten egg" odor can be detected by the human nose at concentrations as low as 0.0005 ppm (Calvert and Englund 1984). Thus, odor is the primary public exposure concern for H_2S, as detection by smell would usually provide a "warning" at concentrations much below levels of health concern. H_2S can only be detected at first, for a short time, before one is desensitized. Exposures of 20-150 ppm may cause mild eye and throat irritation, and if exposure is prolonged, pulmonary edema may result (Sax and Lewis 1989). A 30-minute exposure to 500 ppm results in headache and dizziness, followed sometimes by bronchitis or bronchopneumonia, and exposures of 800-1,000 ppm in 30 minutes could be fatal (Sax and Lewis 1989). H_2S is an acute toxicant. Survivors of H_2S exposure generally recover completely with no residual health problems. There are no known carcinogenic effects. Impacts to vegetation and humans from exposure to H_2S are shown in Table 4.14-6.

Table 4.14-6 Biological Impact Levels of Hydrogen Sulfide

Parameter	H_2S Concentration (ppm)
Vegetation	
No injury to 29 plant species, fumigated for 5 hours.	43.2
No damage to Boston fern, apple, cherry, peach, and Coleus, fumigated for 5 hours.	432
Moderate damage to gladiolus, rose, castor bean, sunflower, and buckwheat, fumigated for 5 hours.	43.2 - 432
Human	
Minimum concentration causing eye irritation.	10.8
Minimum concentration causing lung irritation.	21.6 - 43.2
Olfactory fatigue in 2 - 15 minutes; irritation of eyes and respiratory tract after 1 hour; death in 8 to 48 hours.	108
No serious damage for 1 hour but intense local irritation; eye irritation in 6 - 8 minutes.	194 - 345

Source: Preliminary Air Pollution Survey of Hydrogen Sulfide (1969) prepared by the U.S. Department of Health, Education, and Welfare.

H_2S is expected to be found in the geothermal fluids at levels of 20-100 ppm. The H_2S abatement system would convert H_2S into elemental sulfur and water, both considered nonhazardous. Given the likely concentrations of H_2S and the abatement system, the probability of exposure sufficient to effect human health and safety is small. The main human health concern for exposure of on-site personnel to H_2S is at the plant and the wells. Workers would be protected by detection equipment and alarms at the drill rigs and power plant.

Other potential pollutants include trace elements and heavy metals which would be primarily in particles and droplets and mostly settle to the ground within a short distance from the release points due to their size and weight. Table 4.14-7 lists cancer unit risk factors and reference exposure levels for noncarcinogens published by the State of California (CAPCOA); Oregon does not have comparable standards. The probability of exposure to these pollutants sufficient to affect human health and safety is low.

Table 4.14-7 California Air Toxics Factors[a]

	Carcinogen (Unit Risk Factor) $(\mu g/m^3)^{-1}$	Noncarcinogen (Reference Exposure Level) $(\mu g/m^3)$	
		Chronic	Acute
Ammonia		100	2,100
Antimony		1.2[b]	
Arsenic	3.3×10^{-3}	0.50	
Beryllium	2.4×10^{-3}	0.0048	
Cadmium	4.2×10^{-3}	3.5	
Chromium	1.4×10^{-1} [c]	0.002[c]	
Cobalt		0.12[b]	
Lead		1.5[d]	
Manganese		0.4	
Mercury		0.3	30
Nickel	2.6×10^{-4}	0.24	10
Selenium		0.5	

[a]Source: CAPCOA (1993), except as noted; Oregon does not have comparable standards.
[b]ACGIH 8-hr TWA TLV divided by 420.
[c]Hexavalent portion only (i.e., Cr^{+6}).
[d]National Ambient Air Quality Standard (calendar quarter average).

4.14.3.5. Electric and Magnetic Fields (EMF)

Power lines, like all electrical devices and equipment, produce electric and magnetic fields (EMF). Current (movement of electrons in a wire) produces the magnetic field. Voltage (the force that drives the current) is the source of the electric field. The strength of these fields also depends on the design of the line and on distance from the line. Field strength decreases rapidly with this distance. Some scientists believe that electric and magnetic fields may be potentially harmful and that long-term exposure should be minimized. Hundreds of studies have been conducted in the United States and other countries. These include discussion of above-ground power lines and epidemiological studies of electric workers or other groups in which the subjects are exposed to high and changing magnetic fields. BPA references some of these studies and others in their documents (BPA 1992; 1993c). A review of biological and epidemiological effects from exposure to electric and magnetic fields is provided in Appendix H.

Average electric field strength in a home is typically less then 0.01 kilovolt per meter (kV/m). Table 4.14-8 lists typical electric and magnetic field strengths for some common electrical appliances. Table 4.14-9 shows typical electric and magnetic field strength for a 115 kV transmission line. The values for electric field strength in a 115 kV transmission line right-of-way are well under the standards set by Oregon or BPA (Human Health and Safety, Section 3.14.2.4).

Table 4.14-8 Typical Electric and Magnetic Field Strengths from Common Appliances at a Distance of 0.3 Meter (1 Foot)

Appliance[1]	Electric Field (kV/m)	Magnetic Field (mG)
Coffee Maker	.030	1 - 1.5
Electric Range	.004	4 - 40
Hair Dryer	.040	1 - 70
Television	.030	0.4 - 20
Vacuum Cleaner	.016	20 - 200
Electric Blanket[2]	.01 - 1.0	15 - 100

kV/m - kilovolts per meter
mG - milligauss
[1] By 0.9 to 1.5 meter(s) (3-5 feet), the magnetic field from appliances is usually decreased to less than 1 mG.
[2] Values are for distances from a blanket in normal use, not 1 foot away.
Sources for appliance data: Miller, 1974; Gauger, 1985.

Table 4.14-9 Typical Electric and Magnetic Field Strength For 115 kV Transmission Line Based on Distance from Center of Right-of-Way

Distance Meters (Feet)	Electric Field (kV/m)	Magnetic Field (mG)	
		Average	Peak
0 (0)	1.0	30	63
15.2 (50) (Edge of ROW)	0.5	7	14
30.5 (100)	0.07	2	4
61 (200)	0.01	0.4	1
91.5 (300)	0.003	0.2	0.4

Values for Electric Field strength are for a point 1 meter (3.3 feet) above the ground.

Peak Magnetic Field strength values occur less than 1 percent of the time.

These estimates are typical magnetic field strengths at various distances from BPA ransmission lines and may not be accurate for this transmission line.

Source: BPA (1993c).

In a home, magnetic fields of tens of hundreds of milligauss (mG) can be present when standing very close to appliances carrying high currents. In the middle of a room, away from wiring and appliances, the average magnetic field strength is typically less than 1 mG. The placement of the transmission lines in either alternative would vary and effects are described separately under Alternatives A and B. Unlike electric fields, magnetic fields are not reduced in strength by trees and building material. Currently there are no standards set by the state, BPA, or Federal government with respect to allowable magnetic field strength.

No residences or facilities are located near the project area. Potential receptors of EMF would be limited to workers at the power plant and those traveling or camping in the area. Plant workers would be exposed to EMF during the course of performing their jobs. Presently, there is no way to assess exactly what levels, or for what duration exposures might be for those working at the proposed facility. Those traveling through the area would likely be exposed to low field strengths and for limited duration comparable to exposure elsewhere in the vicinity wherever similar transmission lines are present.

4.14.3.6. Risk of Hunters in the Area

The project location is forested and includes hunting areas. The risk posed by hunters in the area is from three key elements:

- Accidental firing of hunting weapon that can strike plant personnel or plant equipment
- Accidental fires generated by camping hunters
- Exposure of hunters in the vicinity of the plant during a plant emergency

At this time there does not appear to be sufficient reported data on past hunting accidents in the vicinity of the proposed plant site. However, to provide for such events occurring, general procedures and plans to address these issues would be developed. These plans would use public and hunter information as the main tool. This would include

- Public announcements
- Posting of clear and well displayed signs at critical locations
- Brochures and posters provided to licensed hunters entering the designated hunting areas

Making an appropriate safe area around the plant and pipelines as "off limits" to hunters and fuel wood gatherers is part of both alternatives.

4.14.4. Effects Specific to Alternative A

Typical magnetic field strengths for a 115-kV transmission line can be found in Table 4.14-9. These estimates are typical magnetic field strengths at various distances from BPA transmission lines, and may not be accurate for this transmission line.

4.14.5. Effects Specific to Alternative B

Effects for Alternative B would be almost identical to those for Alternative A, and no effects specific to Alternative B are anticipated.

4.14.6. Additional Mitigation Measures

None are proposed.

4.14.7. Effects of Alternative C

No change in baseline conditions would occur under Alternative C. Thus, no effects on human health and safety would occur.

4.15. ECONOMIC AND SOCIAL CHARACTERISTICS

4.15.1. Impact Overview

Effects on social and economic characteristics that are common to geothermal development and utilization are associated with project-related jobs, direct expenditures for supplies, and tax and royalty revenues generated by the project. The potential in-migration of construction and operation workers can result in additional demands on local existing infrastructure (i.e., housing, schools, water supply, sewer, solid waste disposal, law enforcement, fire protection, and health care). If demand for infrastructure exceeded available supply, the timing and amount of anticipated project related revenues that could be used to improve infrastructure are considered when determining project-related impacts.

4.15.2. Method of Analysis

Existing conditions were determined and compared with anticipated changes from Alternatives A and B. Background conditions were established based on material provided by the Central Oregon Economic Development Council, the City of Bend, Deschutes County, and the Bend Chamber of Commerce. Some of the information on anticipated changes from Alternative A was obtained from CEE. Specific assumptions used in the analysis are provided below.

4.15.2.1. Project Exploration Workforce and Schedule

Table 4.15-1 shows the workers that would be associated with drill rigs used for exploration in late 1994 and early 1995. Each drill rig would require about 24 workers. Therefore, there would be 40 to 90 workers associated with exploration. Exploration activities would continue throughout the project. However, once the development phase would begin, the socioeconomic impacts of the exploration workers are considered a part of the impacts of the construction workers.

4.15.2.2. Project Development Workforce and Schedule

Table 4.15-1 presents the estimated development (construction) workforce that would be required each quarter from 1995 through early 1998 to build the project. Following project approval, production drilling is anticipated to begin in the spring of 1995 with one drill rig and two core rigs. A second drill rig, and possibly a third, would be added in the third quarter of 1995. Power plant construction would begin in the fourth quarter of 1995 and therefore by the fourth quarter there would be a total of about 131 construction workers on site. Work would shut down during the winter and begin in the spring of 1996 and the construction workforce would peak between 220 to 250 workers in the third quarter of that year (during August and September) when work on all components of the project would be underway. The transmission line and the pipeline would be completed by the fall of 1996, while the final pipeline connection and power generation system connection would occur in the summer of 1997. In addition to the construction crews, there could be an additional 30 people on site including suppliers and governmental representatives.

Power plant construction would require both skilled and unskilled labor. The type of labor needed by project component is presented in Table 4.15-2. About 50 to 60 percent of the skilled labor for power plant construction and almost all the management would come from outside Central Oregon. Pipeline and drilling crews would largely be nonlocal, and about 50 percent of the transmission line construction crews would be nonlocal. Therefore about 50 percent of the skilled labor and all of the unskilled labor for the power plant and transmission line labor would be local. Based on these assumptions, Table 4.15-1 also presents the breakdown of the total construction workforce by source of labor (local and nonlocal).

Table 4.15-1
Construction and Operations Workforce and Schedule

	1994	1995				1996				1997				1998
Component/Quarters	4	1	2	3	4	1	2	3	4	1	2	3	4	1
Construction														
Well Drilling	25		25	75	50		50	50	25		25	25	25	
Power Plant and Access					65		65	100	80	40	65	30	10	
Pipeline							25	40	45		10			
Transmission Line							10	20	20		5			
Core Drilling	6		6	6	6		6	6	6					
Management	10	10	10	10	10	10	10	10	10	10	10	10	10	
Subtotal	41	10	41	91	131	10	166	226	186	50	115	65	45	
Operations											10	25	25	25
Total	41	10	41	91	131	10	166	226	186	50	125	90	55	25
No. of Workers by Source														
Nonlocal	41	10	41	91	98	10	128	166	136	30	92	63	38	13
Local	0	0	0	0	33	0	38	60	50	20	33	27	17	12

4.15.2.3. Project Utilization Workforce and Schedule

Project utilization (operation) would require about 25 permanent employees. Approximately half of these positions are expected to be filled with trained operators from outside Central Oregon and half filled by local hires. These new employees would be hired in the second and third quarters of 1997, because power plant start-up would occur between December 1996 and July 1997. The start-up would last 4 to 6 months, and the plant would be operational by the fourth quarter of 1997.

4.15.2.4. Project Decommissioning Workforce and Schedule

The decommissioning of the geothermal facility would require one-third to one-half the number of workers that would be required for construction. Decommissioning would take less than 1 year and would take place about 50 years in the future.

Table 4.15-2 Labor Skills Required for Project Construction

Component	Skills	
Power Plant	Skilled:	Electricians, pipe fitters, welders, carpenters, heavy equipment operators.
	Unskilled:	Helpers, apprentices, general laborers.
Pipeline	Skilled:	Welders, equipment operators, electricians, pipe fitters, insulators.
	Unskilled:	Welders helpers, general laborers
Drill Rigs	Skilled:	Professionals, drilling engineer, geologist, mud logger, drilling superintendent.
	Unskilled:	Tool pushers, rough necks, mud mixers, yard hands, general labors.

4.15.2.5. Other Assumptions

The majority of the exploration and construction workers would be nonlocal and would migrate to the study area for the duration of their employment. Given that exploration and construction would be suspended during winter months, it was assumed that nonlocal exploration and construction workers would be in the area for about 9 months each year of construction. Power plant construction would involve a number of phases — civil work/site preparation; road building; installation of structural steel; installation of mechanical equipment, electrical and control equipment. Therefore, the construction crews at the power plant would change. Except for well drilling, core drilling, pipeline and transmission line workers, other crews would be in the area for short periods of 3 to 6 months.

For the analysis of population impacts, it was assumed that half the nonlocal construction workers would be single or not accompanied by families, and that those accompanied by families would have an average family size of 3.75, with 0.79 school-aged child per family (both numbers are averages for the state of Oregon from the 1990 Census).

4.15.3. Effects Common to Alternatives A and B

4.15.3.1. Population

Based on the assumptions listed above, the study area population would increase by 120 persons during exploration; then the study area population at peak would increase by 477 persons during project development, with the majority of this nonlocal population (50 to 70 percent) located in Bend, and about 10 percent in Redmond. LaPine, although small in size, could attract some of the nonlocal workers due to its proximity to the project site. The influx of the nonlocal workers and their dependents into Bend would temporarily increase the population of the community by about 330 persons (at peak) or 1.3 percent over 1992 population levels. Given the high growth rates that Bend has been experiencing, the project-related temporary population increase would be relatively small. Other communities would experience smaller population increases.

Project utilization would result in about 13 permanent employees relocating to Bend. Assuming that all these employees are accompanied by families, the City's population would increase by about 50 persons.

Population changes during project decommissioning would result in up to about 150 to 250 persons. This would only be a slight increase from the stable utilization phase population. Once decommissioning was completed, the workers would either leave the area or settle, depending on the socioeconomic characteristics of the area at that time in the future.

4.15.3.2. Economy and Employment

Project exploration, development, utilization, and decommissioning would not affect the sectoral distribution of jobs because of the small numbers of jobs associated with these phases. Project development would, at peak, create 226 construction jobs of which about 60 would be filled by local hires. At other times during construction the number of jobs accruing to local workers would vary between 15 and 38. Given the large pool of unemployed labor in the three-county area (4,820 persons in 1992), these jobs, though beneficial, would not significantly change the unemployment levels in the study area. Given the short construction period, the indirect and induced employment effects of these construction jobs would likely be limited.

Project utilization would create a total of about 25 permanent operations jobs of which 12 would likely be filled by local workers. The direct utilization jobs would also create indirect and induced jobs. However, this beneficial employment impact would also be less than significant. Project decommissioning would result in an effect similar to project development on a smaller scale.

As discussed in Section 4.9, Recreation, the project would not result in any significant impacts to recreation resources in the study area; therefore, a loss of tourism income would not occur. Analysis reveals that there might be a small increase in the visitor use of the area. Hunting is also not anticipated to be affected by the project because, except for the power plant itself, no other areas would be closed off.

4.15.3.3. Housing and Lodging

During the exploration phase, there would be 40 to 90 nonlocal workers in the study area. This would increase to a peak of 166 nonlocal workers during the development phase. At least half of these (about 83) would likely be single and/or not accompanied by families, and would likely use transient lodgings for duration of their stay. As noted in Table 3.15-1 there are about 2,100 lodging units in Bend and another 2,000 in the remainder of Deschutes County. Based on the annual occupancy rate of 55 percent, about 945 hotel/motel units in Bend and about 1,890 units in the county are available at a given time. About 83 units required by the single construction workers at peak would represent a very small fraction of the available lodgings in the area. Construction workers accompanied by families would either utilize motel/hotel units, rental vacation homes, or rent homes and apartments. The availability of housing in the Bend area is limited. (The current vacancy rate is about 2 percent or about 180 vacant homes/apartments). However, rental vacation homes are also available in the Bend urban area. Therefore, the project would not result in a demand for housing that could not be met by the available resources.

Nonlocal project operation employees would require 13 homes and apartments in Bend. These should be available and would not represent a demand that could not be met by local resources. Decommissioning would require 50 to 80 workers. This demand could be served by the existing available resources. Actual impacts will depend on the socioeconomic conditions in the future.

4.15.3.4. Schools

Based on an average of 0.79 school-aged children per construction worker family, the exploration phase, with an average workforce of 50, could bring 25 families with 20 school-age children to the area. During development, an average construction workforce of about 40 nonlocal workers (with families) during the exploration and development phases, the number of school-aged children in the study area would increase by 32. These students would be mostly elementary school and junior high school children. At 30 to 35 students per classroom, this would represent one additional classroom. During the peak of construction in 1996, about 128 to 166 nonlocal construction workers would be in the study area over three quarters of that year. Assuming that half of these workers would be accompanied by families during these 9 months, the school-aged children in the study area could increase by about 60. As most of these families would move into Bend, the Bend/LaPine School District would be affected. As noted in Section 3.15, the enrollment in the school district has been growing rapidly, and most schools are at capacity.

The 13 nonlocal operation employees during the utilization phase would be accompanied by about 10 school-aged children. There would be an increase in school-aged children during the decommissioning phase. The actual impact would depend on the available capacity in the schools in 50 years.

4.15.3.5. Utilities and Services

Given the availability of excess capacity in the water and wastewater system in Bend and other affected communities, the influx of nonlocal workers and their dependents during exploration, development, utilization, and decommissioning, would not impact these utilities. The new population in Bend (330 nonlocal persons at peak) would not significantly lower the service ratios as far as law enforcement is concerned. The project would not affect the resources of the nearby fire departments, or other emergency services.

The annual output of the geothermal project will be about 261,000 MWh, which is about what Midstate Electric Cooperative now purchases from BPA. Because the project would be a small (30 MW) addition to BPA's resources (21,629 MW), it would not have a discernible impact on the cost of electricity.

4.15.3.6. Public Finance

The total capital cost of the project is estimated at $93 million. Development of the project would yield revenues for Deschutes County in the form of property taxes and royalties. There would only be a minor amount of revenue generated during the exploration phase. Project development would increase the assessed value of the project site, and about $1,260,000 would be paid by the owner/operator to Deschutes County in property tax each year. Another potential source of public finance is a 10 percent geothermal operating royalty paid to the Federal government. Half of all these royalties are returned to the state. Oregon passes the state share through to the county of origin, as per Oregon Revised Statutes 294.055. Royalties are based on the gross proceeds to a developer from the sale of steam or electricity, and are paid when a geothermal facility is operating. Presently, there are no royalties collected in central Oregon. During utilization, the Federal royalties from the extraction of steam would be approximately $480,000 per year, half of which would accrue to Deschutes County. The county will decide how these funds are to be used.

The regional economy would benefit from spending during the exploration, development, and utilization phases of the project to the extent that construction materials, equipment and supplies for the power plant are purchased or rented from regional vendors. This spending would create additional income through the income multiplier process. Payroll spending would also generate additional income. A study of the economic impacts of geothermal development in Deschutes County conducted by the Oregon Department of Energy (Sifford and Beale 1991) estimated that every $1,000 of take-home pay resulting from geothermal development would generate $393 additional income to businesses and individuals in the county. Assuming an average salary/wages of $40,000 per year for the 25 operations employees, the annual operations payroll would be around $1 million. This would yield an annual personal income tax for the state of about $90,000. Assuming 60 percent of the wages would be take-home pay, about $600,000 would be spent in the regional economy. Through the multiplier process, this would generate additional income of about $218,000 each year. The distribution of these royalties between various funds by the county is not decided at this time. The County Budget Board would meet to determine the distribution (Rastovich 1993). Economic impacts during decommissioning would result in generation of tax revenues from payroll. Property tax would likely decrease as the value of the property decreased. The property tax following decommission would depend on the ultimate use of the project. Deschutes County would no longer receive its share of royalties from steam sales.

Another potential source of public finance is a 10 percent geothermal operating royalty paid to the federal government. Half of these royalties are returned to the state. Oregon passes the state share through to the county of origin, as per Oregon Revised Statutes 294.055. Royalties are based on the gross proceeds to the developer from the sale of steam or electricity (or other products, such as the sulfur removed during the hydrogen sulfide abatement process), and are paid when a geothermal facility is operating. Presently, there are no geothermal royalties collected in Central Oregon.

4.15.4. Effects of Alternative A

Implementation of Alternative A would result in the impacts described in Section 4.15.3. No additional impacts would occur.

4.15.5. Effects of Alternative B

Implementation of Alternative B would result in the impacts described in Section 4.15.3. No additional impacts would occur.

4.15.6. Additional Mitigation Measures

None are proposed.

4.15.7. Effects of Alternative C

Under the no-action alternative, the geothermal resource would not be developed and the power plant would not be built, and no socioeconomic changes would occur in the study area.

4.16. CUMULATIVE EFFECTS

4.6.1. Introduction

Cumulative impacts are defined as those incremental impacts resulting from the proposed action and from other past, present, and reasonably foreseeable future actions that would or could have a greater combined effect over space and time. Existing conditions are described in Chapter 3. Direct and indirect impacts are described earlier in this chapter. This section provides an overview of the potential direct and indirect impacts as they may occur over time, within the context of impacts that would result from various actions that are unrelated to the proposed geothermal development, and which can be foreseen with various degrees of certainty. Two time frames, short- and long-term, are addressed in this section. There is more certainty about what would be likely to happen in the short term, consequently those impacts are addressed in more detail. The longer-term future is less predictable, and addressed only generally for that reason and because the CEQ guidelines (Council on Environmental Quality 1992) do not favor speculation about unknown future events.

4.16.2. Current Activity and Short-term Future Conditions and Effects

This section provides a description of current activities that have effects on the environment of the project area, vicinity, and region. It also includes an estimate of the short-term future effects of various activities and observed trends. These projects and their environmental effects can be thought of as part of a "backdrop" against which the proposed geothermal project's effects can be addressed, and which may also affect the proposed geothermal pilot project. In this context, "short-term" is defined as within the next approximately five years. Only those actions, trends, or planned actions which have been formally proposed or are being initiated in some substantive way are included in this analysis

4.16.2.1. Timber Sales

Within the last twenty years, an estimated 30 to 40 percent of the available timber lands in the Fort Rock Ranger District have had some harvesting done. This timber sale activity has reduced or altered suitable habitat for all MIS and other wildlife and has changed the landscape at Newberry from one of largely contiguous forested habitats affected by prolonged drought and insect damage to a pattern of harvested and unharvested areas and an even-age growth of young lodgepole and open ponderosa pine. Mixed forest habitat occurs in isolated patches, with the remaining large blocks of mixed conifers located within protected areas, such as riparian zones and the NNVM. Timber harvest has also resulted in increased road densities in the project area and vicinity, increased traffic and intermittent noise, and radically changed visual characteristics. The current mosaic pattern is expected to continue over the short-term.

Habitat for cavity-using wildlife species and others that thrive in older forests of lodgepole, ponderosa, and mixed conifer with a large proportion of dead trees has been reduced by recent salvage logging. Even without development of a geothermal power plant in the project area, continued timber harvest and associated road construction may occur over the short-term, potentially altering the suitability of the project area for deer and elk during the summer, unless public access to these areas were to be prevented.

The U.S. Forest Service long-range plan does not indicate any additional sales in the vicinity of the plant sites and well pads in the portion of the SO lease area north of Paulina Creek. The Prairie Dog Timber Sale could affect vegetation and habitat in the SO lease area south of Paulina Creek.

4.16.2.2. Deschutes Land and Resources Management Plan (LMP) Implementation

The changes that have already occurred in the Deschutes National Forest in the vicinity of the proposed geothermal pilot project are consistent with the current Forest Land Management Plan, which allows for consideration of geothermal development. The North Paulina Roadless Area would be reduced in size by about 6 percent (this is the gross lease area, not the area devoted to project facilities) if the proposed geothermal development were to occur.

4.16.2.3. Population Growth in the Bend Area

The rate of population growth in the Bend area is considered to be the second highest in the state, with a projected rate over the next 5 years of 2.5 percent per year. This high growth rate is already having impacts on smaller surrounding communities and is expected to lead to increased pressure for rural residential development as well as urban growth. The overall increased population growth would likely have diverse impacts on the region, including the need for more energy. This increasing need could contribute to an interest in or demand for additional geothermal power development located in the area, rather than importing energy from more distant sources, or using more conventional sources such as hydroelectric, fossil fuel, or nuclear power.

Increased populations can also be expected to use more recreational resources and will probably contribute to increased visitation at the NNVM, Deschutes National Forest, and other areas. The first geothermal power plant at Newberry is also to be a likely item of recreational and educational interest to this population.

4.16.2.4. Newberry National Volcanic Monument (NNVM)

Regardless of the management alternative ultimately chosen for the NNVM, the visitation to the NNVM, and to a lesser extent adjacent areas, is expected to increase. The amount of increase and the types of uses that will be allowable have yet to be determined. With the expected growth rate in Bend of 2.5 percent per year, visitation and recreation pressure in the NNVM could increase at a comparable rate, until some upper limit or carrying capacity is reached. This limit may either be built into the Monument Plan through limits to facilities (such as campgrounds, lodging, and parking spaces) or be intrinsic limits, for example, people would cease to visit an area that no longer meets their requirements for solitude or some other facet of recreational experience. Increased use of the NNVM is likely to increase the public interest in the geothermal development occurring just outside the NNVM. This interest may lead to increased public use of the area resulting in increasing problems of trespassing, vandalism, poaching, road kills to wildlife, and fire hazard.

4.16.2.5. Water Use and Regulation by the Oregon Water Resources Department

Surface water resources for Deschutes County, including Paulina Creek, are fully "appropriated," and the Oregon Water Resources Department (WRD) no longer grants new surface water rights. Concern has been raised by the WRD that groundwater resources may become depleted with continued development. A comprehensive groundwater resources study for the county and surrounding area is being undertaken by the USGS and the WRD (1993). The status of CEE's water rights application for 3.08 million cubic meters (2,500 acre-feet) per year of water to be obtained from the shallow aquifers that overlie the geothermal reservoir may be affected by the current uncertainty about new water rights. Conflicts with an expanding population's need for more water could also affect the availability of water to the geothermal pilot project. The viability of the proposed geothermal pilot project could be affected.

4.16.2.6. Geothermal Development by CEE

Incremental, cumulative, physical effects of the proposed geothermal pilot project include the following, which have been described in detail in previous sections:

- Slight increase in current road density
- Slightly increased traffic
- Clearing of 119 hectares (295 acres) of vegetation
- Create a visible steam plume during well testing
- Withdraw 3.08 million cubic meters (2,500 acre-feet) of shallow groundwater or approximately 1 percent of the estimated total regional groundwater recharge, assuming a water right is granted by the Oregon Water Resources Department
- Create slight impacts on air quality
- Have slight effects on recreational use

- Generate about $1 million in property taxes annually to Deschutes County and approximately $240,000 per year for Deschutes County from Federal royalties

- During construction, bring in up to an estimated additional 60 students in local schools

- Reducing the North Paulina Roadless Area by approximately 6 percent, which is provided for in the Forest Plan

None of these impacts listed above are particularly significant, when viewed in the context of the other trends occurring in the vicinity which were described in previous sections. The significant impact of this project is that if successful, it could open the way for more proposals for geothermal developments in the Newberry vicinity by CEE or other companies. The contract for power sales between CEE and BPA is for up to 130 MW, which considers possible future projects.

4.16.2.7. Geothermal Development by Others

Vulcan Power is the only other geothermal company that has expressed interest in obtaining permits and drilling test wells in the short-term future. A power plant is unlikely to be developed within the short term. If the Newberry geothermal pilot project is successful, interest by Vulcan and/or other geothermal developers could be stimulated and development time frames speeded up.

The amount of geothermal fluid to be withdrawn from the reservoir by well testing during the short term is expected to be relatively small. Supplemental reinjection of waters derived from shallow groundwater wells is not expected to be a part of Vulcan's drilling program because the amount to be withdrawn is so small.

4.16.3. Longer-term Future Conditions and Effects

4.16.3.1. Timber Sales

Incremental medium level impacts may occur to visual resources resulting from future timber harvesting activities. Future harvesting could remove vegetation screening adjacent to the proposed plant site location and several well pad locations including I-28 and K-28. These changes to the landscape could be visually dominating to this partial restoration visual quality standards area. These activities could draw visual attention from the NNVM, particularly from Paulina Peak and segments of the Rim Trail. As new areas are logged, other areas would grow toward maturity and the boundaries between logged areas may become less distinct over time.

4.16.3.2. Deschutes LMP Implementation

The Deschutes LMP identifies areas thought to be suitable for geothermal power development, thus future development of these areas would be consistent with and fulfilling current plans with allowable uses of resources.

4.16.3.3. Population Growth in Bend Area

Continuing population growth in the Bend area would contribute to increased demand for facilities, services, water, and energy. If these trends continue and the first geothermal development is successful, pressure for additional power development, perhaps to supply the Bend area, would increase.

4.16.3.4. Newberry National Volcanic Monument

NNVM use is likely to continue to rise in the future until the planned-for capacity is reached. Pressure for additional development in fringe areas or portions of the Monument to the north of the project area could create additional future conflicts with geothermal exploration and development.

Conflicts could include visual impacts from new viewpoints and campgrounds, conflicts of tourist vs. construction/operation traffic, and complaints about noise or odor if future recreational facilities are sited in ways that could conflict with future geothermal development.

4.16.3.5. Geothermal Development by CEE and Others

New geothermal development by CEE and other entities could produce additional steam plumes which could draw more visual attention from viewing locations. The plumes would create an additive impact to visual resources. Additional new development would require night time illumination and could result in an additive night glow effect. Depending upon the specific location of these activities, their number, and the visual absorption capacity of these locations, the night glow may or may not be a substantial impact.

It is impossible to estimate the amount of geothermal resources available for development 6 to 50 years into the future. Thus, the number of plants (and therefore plumes) that might be developed over 50 years at Newberry could be low — one to three plants, for instance — or a higher development scenario might include several more plants dispersed throughout the West Newberry area, North Newberry, and Transferral Area . Development at the higher density would likely have cumulative effects (water, road traffic, noise, etc), although individually they would likely be similar to Alternatives A or B.

Development of multiple geothermal power plants over the long term, even to a high development scenario, are not expected to cause adverse cumulative effects to air quality. They are likely to be rather indiscernible from the general deterioration of air quality likely to occur in the Bend vicinity from increasing population, automobiles, boats, lawn mowers, land clearing, and increased chance of fire owing to more people in the area.

More geothermal power plants with associated roads, transmission lines, and pipelines would cause a reduction in availability and quality of wildlife habitat for big game and forest dependent species. Those impacts could be offset by appropriate mitigation measures, such as supplying water in areas where no drinking water existed before, closing roads to public access to reduce disturbance to wildlife, protection of mature stands for MIS species, and creation of snags.

As land manager, the Deschutes National Forest prefers to consolidate utility lines where possible, and not have multiple corridors. Analyses of any future projects will include utilizing existing power lines or utility corridors. The conductor proposed for the transmission line has a capacity that could accommodate up to 100 MW. This will reduce the likelihood of additional transmission corridors if future development did occur.

The net socioeconomic effects of this type of buildout scenario are positive because of the tax and royalty benefits accrued by Deschutes County. The increased population of workers over the long term, needed for both construction and operation of additional power plants, would not be noticeable within the current high rate of growth of the area. If growth slows, the effects are likely to still be insignificant because of the relative size of the socioeconomic resources available in the Bend area.

The contract for power sales between BPA and CEE has clauses which provide for the purchase of up to 130 MW of total output. The fact that these items have been considered in no way means that additional development or power plants is guaranteed or has already been decided. Additionally, although one aspect of BPA's Pilot Project is to demonstrate that there is a 100-MW reserve, this does not mean it will be developed. This is not a predetermined multi-stage project. Any additional development would have to be evaluated for its environmental impact.

Any future development would have to be consistent with Forest Service plans and policies at that time. The Monument Legislation and the Deschutes Forest Plan prohibit development in the crater.

4.17. UNAVOIDABLE ADVERSE IMPACTS

Based upon the analyses conducted for this report, a number of unavoidable adverse impacts were identified. Other, more substantial potential impacts were prevented by incorporating environmental protection features into the project design and operation.

Those impacts with a high likelihood to occur that cannot be mitigated include:

- Reduction of the North Paulina Roadless Area by 6 percent (which is allowed for in the Forest Plan)
- Long-term adverse impacts to deer and elk summer use areas
- Small reduction of available timber lands (119 to 123 hectares [295 to 303 acres])
- Deterioration of recreational experience in the vicinity of the project
- Increase in construction work force which could result in temporary impacts to local schools
- Increase in traffic from construction-related activities
- Visual impacts from Paulina Peak, the Rim Trail, and to a lesser extent, other areas

Those impacts with a moderate to low likelihood to occur that cannot be mitigated include:

- Water quality degradation in the event a sump overflows
- Small changes in local and regional groundwater levels
- Increased noise during construction and operation in the vicinity
- Detectable H_2S odor within approximately 6 km (3.7 miles) of the power plant due to unplanned upsets occurring during poor meteorological dispersion conditions

Each of these impacts are discussed in great detail in Section 4.0. None of these impacts are considered to be significant.

4.18 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

While this project would result in the short-term commitment of certain resources, it is expected to be the first step in identifying an alternate source of energy in Oregon. This project would provide environmental advantages over traditional power generation sources such as reduced emission of air pollutants, reduced land-use requirements, no impacts to rivers and fish habitat, and some potential for renewability. The project would have the long-term benefit of identifying a geothermal resource that can supply the electricity needs for approximately 30,000 people during the life of the project, and relieving some of the initial impacts associated with other generation sources.

For socioeconomic issues, the 50-year life of the project would be considered part of the long-term productivity for the area. The short-term socioeconomic effects of the construction period would be offset by the long-term increase in jobs and revenues and the potential for other positive impacts from future development by CEE or other geothermal companies. For example, royalties accrued to the Federal government would exceed those of timber revenues over the life of the project.

The long-term productivity of biological resources would not be affected by the proposed project. Once the project was abandoned, the surface area would be restored to its natural conditions.

4.19. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

There are several anticipated effects of this geothermal pilot project that are basically irreversible.

The first is that if the pilot project is approved and successful, demonstrating that geothermal power is feasible at Newberry will set a precedent for the Deschutes National Forest. The success of this initial project will act as a catalyst or stimulus that generates increasing interest on the part of other developers of geothermal power that have interests or leases at Newberry.

The second essentially irreversible effect of the proposed project is that the portion of the Project Area that is currently roadless (in the North Paulina Roadless Area) will become roaded. It is highly unlikely that this area will ever be allowed tc revert to a roadless condition, especially since its conversion to a roaded area is provided for in the Forest Plan.

There may also be some land uses within the Project Area that will be inhibited or even prevented over the long term by a successful geothermal power plant. These uses include avoidance by big game of newly roaded areas if public access is provided, adverse effects on recreational use and views, and other uses of local shallow groundwater.

4.20. ALTERNATIVE EFFECTS ON MINORITIES AND WOMEN

Minorities and women would be affected by changes in job and recreation opportunities. New jobs would be created if one of the action alternatives were to be selected. Recreation and hunting opportunities would also change if one of the action alternatives were to be selected.

4.21. CONSISTENCY WITH OTHER PLANS AND POLICIES

Plans and policies of various federal, state, county and city agencies were reviewed for consistency with the alternatives addressed in this EIS. All of the alternatives were determined to be consistent with the 1980 Resource Planning Act, the Deschutes County Comprehensive Plan, U.S. Fish and Wildlife Service Endangered Species Recovery Plans, the State Comprehensive Outdoor Recreation Plan, Oregon Department of Transportation, Fill and Removal administered by the Oregon Division of State Lands (ORS Chapters 274, 517, and 541), and Section 404b (1) of the Clean Water Act administered by the U.S. Army Corps of Engineers. Additional plans and policies listed below are addressed more specifically.

<u>1991 Pacific Northwest Conservation and Electric Power Plan</u>
The project is consistent with recommended actions in the Geothermal Confirmation Agenda of the Northwest Power Planning Council's 1991 Power Plan.

<u>State Energy Facility Siting</u>
The Oregon Department of Energy's Energy Facility Siting Council's (EFSC) Rules (Chapter 345 Divisions 1-25) would be followed and a Site Certificate would be obtained before the power plant construction could proceed.

<u>Air and Water Quality Regulations and Statutes</u>
All alternatives would meet the provisions of and regulations in response to the Federal Clean Air and Water Acts. The Plans of Operations prepared by CEE were designed to comply with the Oregon Administrative Rules (OARs) for air and water regulations as administered by the Oregon

Department of Environmental Quality in response to Oregon Revised Statutes (ORS 468.275 to 468.345 and ORS 468.700 to 468.775).

Fish and Wildlife Habitat Policies and Regulations
The alternatives would not conflict with habitat management plans and policies of Oregon Department of Fish and Wildlife and U.S. Fish and Wildlife Service endangered species policies.

Cultural Resources Regulations
All actions would comply with Federal historic preservation law and regulations, including Executive Order 11593, Section 106 and 110 of the National Historic Preservation Act of 1966, the American Indian Religious Freedom Act, and the Archaeological Resources Protection Act of 1979, as amended.

Water Withdrawals
All alternatives would comply with Oregon Department of Water Resources policies and requirements for water withdrawals (ORS Chapters 536 and 543) and groundwater protection.

Drilling Regulations
All alternatives would comply with geothermal drilling regulations administered by the Oregon Department of Geology and Mineral Industries (ORS Chapter 522).

Forest Practices
All alternatives would comply with the Forest Practices Act administered by the Oregon Department of Forestry (ORS 496.012 to 496.162 and ORS 506.105 to 506.201.

Forest Plan
All alternatives would be consistent with the Deschutes National Forest Land and Resource Management Plan (as amended), which includes a provision for geothermal development on the lands where the project is proposed. The proposed project and alternative is consistent with the Deschutes National Forest Land and Resource Management Plan, and with the management allocations in which the project and lease areas are located. These allocations are "M8, General Forest" and "M9, Scenic Views". Refer to the Forest Plan for more information, but briefly, direction in M8 states that geothermal leases will be issued. Conditional surface use and seasonal restrictions stipulations will be used to protect wildlife habitat and recreation areas that are within the General Forest area. Direction for M9 states that mineral developments, utilities, and electronic sites may be located in these areas if facilities and associated improvements are located, designed, and maintained to blend with the characteristic landscape. Visual quality objectives may not always be met when the viewer is within the special use site itself due to the large scale of the facilities, however, when viewed from travel routes, recreation areas, and other sensitive viewer locations, visual quality objectives should be met.

Additionally, the proposed project is consistent with Forest Management Goals which provide for exploration, development, and production of energy resources on the Forest while maintaining compatibility with other resource values. In describing the Desired Future Condition of the Forest, the Plan recognizes geothermal facilities, and describes them by stating that geothermal leases and permits have been issued in a timely manner. Drill pads, pipelines, power plants, and electrical transmission lines, to the extent possible, are designed and located to minimize impacts on other resources, particularly visual quality.

Newberry National Volcanic Monument Act
All alternatives would comply with the provisions of the NNVM legislation (P.L 101-522), and the NNVM Comprehensive Management Plan when approved. For more information on how the project relates to the NNVM, see section 1.6.3.

Eastside Resource Management Plan
The Eastside EIS is currently in progress and is not intended to delay other projects curently being analyzed through NEPA processes. Coordination and communication with the Eastside EIS team

has verified that the geothermal project is not in conflict with the strategies and decisions to be made in that programmatic document.

4.22. ENERGY REQUIREMENTS OF THE ALTERNATIVES

Energy requirements would not change if the no-action alternative is selected. Energy would be generated if one of the action alternatives was chosen. Alternative B would also be designed to eventually supply a more dependable power supply to the NNVM.

4.23. EFFECTS ON PRIME FARMLANDS, FOREST LANDS, AND RANGELAND

Prime Farmland
The USDA Soil Conservation Service has defined prime farmland as:

Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, and oilseed crops and is available for these uses. It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods.

The final environmental impact statement for the 1990 Forest Plan for the Deschutes National Forest concluded that no prime farmlands are found within the boundaries of the Forest.

Prime Forest Land
Prime Forest Land has been defined primarily in terms of its ability to grow wood. The definition states:

Prime timberland is land that has soil capable of growing wood at the rate of 85 cubic feet or more/acre/year (accumulation of mean annual increment) in natural stands and is not in urban or built-up land uses or water. Generally speaking, this is land currently in forest, but does not exclude qualifying lands that could realistically be returned to forest. Delineation of these lands will be in accordance with national criteria.

Under this definition, none of the forested land within the project area would qualify as prime forest land.

Rangeland
Prime rangeland is defined as:

Rangeland which, because of its soil, climate, topography, vegetation, and location, has the highest quality or value for grazing animals. The (potential) natural vegetation is palatable, nutritious, and available to the kinds of herbivores common to the area.

There are no grazing allotments within the project area.

4.24. EFFECTS ON WETLANDS AND FLOOD PLAINS

Wetlands
Wetlands are those areas that are inundated by surface or groundwater with a frequency sufficient to support and, under normal circumstances, do or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas, such as sloughs, potholes, wet meadows, river overflows, mudflats, and natural ponds.

There are no wetlands within the project area.

Flood Plains

The term "flood plain" means the lowland and relatively flat areas adjoining inland and coastal waters, including floodprone areas of offshore islands, including, at a minimum, those that are subject to a 1 percent or greater chance of flooding in any given year.

There are no floodplains within the project area.

5.0
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6.0
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7.0
LIST OF AGENCIES TO WHOM COPIES OF THE DEIS WERE SENT

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FEDERAL AGENCIES

Advisory Council on Historic Preservation
Bonneville Power Administration
Environmental Protection Agency
Federal Aviation Administration
Federal Energy Regulatory Commission
Federal Highway Administration
Federal Railroad Administration
General Services Administration
Interstate Commerce Commission
National Park Service
National Parks & Conservation Association
U.S. Bureau of Land Management
U.S. Bureau of Reclamation
U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of Defense
U.S. Department of Energy
U.S. Department of Housing & Urban Development
U.S. Department of the Interior
U.S. Department of Transportation
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey
U.S. Office of Economic Opportunity

STATE OF OREGON AGENCIES

Department of Land Conservation and Development
Economic Development Department
Executive Department
Forestry Department
Governor's Forest Planning Team
Northwest Power Planning Council
Oregon Department of Agriculture
Oregon Department of Energy
Oregon Department of Environmental Quality
Oregon Department of Fish & Wildlife
Oregon Department of Forestry
Oregon Department of Geology & Mineral Industries
Oregon Department of Human Resources
Oregon Energy Facility Siting Council (EFSC)
Oregon Division of State Lands
Oregon Parks & Recreation Department
Oregon Water Resources Department

LOCAL AGENCIES

Central Oregon Irrigation District
Central Oregon Labor Council
Deschutes County
Deschutes County Environmental Health Division
Deschutes County Planning Commission
Klamath County
Washington Division of Geology/Earth Resources

TRIBES

Confederated Tribes of the Warm Springs Reservation
Klamath Tribe

8.0
ACRONYMS AND GLOSSARY OF TERMS

8.1 ACRONYMS

AAL	acceptable ambient level
ACHP	Advisory Council on Historic Preservation
ADT	average daily traffic
BLM	Bureau of Land Management
BP	before present
BPA	Bonneville Power Administration
CEE	CE Exploration Company, Portland, Oregon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CH_4	methane
CO_2	carbon dioxide
CIEA	Consultants in Engineering Acoustics, San Francisco, California
CSAMT	controlled source audio magnetotelluric survey
dBA	decibel, A-weighted. The A-weighting refers to a technique by which the response of the noise measurement system reflects the relative sensitivity of the human auditory system to the frequencies (in Hz, or cycles per second) comprising a sound or noise.
dbh	diameter at breast height (a measure of tree density)
dBL	Lx dB statistical distribution of noise level in decibels (noise measurement)
DEIS	Draft Environmental Impact Statement
DEQ	Oregon Department of Environmental Quality
EA	environmental assessment
EFSC	Oregon Energy Facility Siting Council
EIS	Environmental Impact Statement
EMF	electric and magnetic fields

EPA	Environmental Protection Agency
EVC	existing visual condition
EWEB	Eugene Water & Electric Board
FAA	Federal Aviation Administration
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FLMP	Forest Land Resource and Management Plan
GDP	Geothermal Drilling Permit
GRO Orders	Geothermal Resources Operational Orders
GUP	Geothermal Utilization Permit
Hg	mercury
HP	high pressure
H_2S	hydrogen sulfide
KGRA	Known Geothermal Resource Area
KOP	Key Observation Point
kV	kilovolt
Leq	equivalent sound level
MSDS	Material Safety Data Sheet
MIS	Management Indicator Species
MW	megawatt
N_2	nitrogen
NAAQS	National Air Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NH_3	ammonia
NNVM	Newberry National Volcanic Monument
NO_2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System

NRHP	National Register of Historic Places
NSO	no surface occupancy
NWPPC	Pacific Northwest Power Planning Council
O_3	ozone
ODOT	State of Oregon Department of Transportation
OSHA	Occupational Safety and Health Administration
Pb	lead
pH	measurement of alkalinity or acidity
PM_{10}	respirable fraction of particulates; those below 10 microns
PMOA	Programmatic Memorandum of Agreement
POD	Plan of Development
POO	Plan of Operations
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
PUD	Plan of Utilization and Disposal
RA	roadless area
RCRA	Resource Conservation and Recovery Act
RGPMOA	Railroad Grade Programmatic Memorandum of Agreement
RMI	Resource Management International, Portland, Oregon
^{222}Rn or Rn-222	radon-222
ROD	Record of Decision
ROS	Recreation Opportunity Spectrum
ROW	right-of-way
SADT	seasonal average daily traffic
SAIC	Science Applications International Corporation
SER	significant emission rate
SHPO	Oregon State Historic Preservation Officer

SL	Site License
SMA	Special Management Area
SO	surface occupancy
TCH	temperature core hole
TDS	total dissolved solids
TES	threatened and endangered species
TGH	temperature gradient holes
TSP	total suspended particulates
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VAC	visual absorption capability
VOC	volatile organic compounds
VRM	visual resources management
VQO	visual quality objective
VQS	visual quality standard
WCC	Woodward-Clyde Consultants

8.2 GLOSSARY OF TERMS

Alternative A	The project as proposed by CEE.
Alternative B	Alternative to the proposed project.
Alternative C	The no-action alternative.
Ambient	Surrounding area.
Aquifer	A subsurface rock unit from which water can be produced.
Area of visual influence	That portion of a landscape falling within a person's cone of vision.
Background	The area of a distance zone which lies beyond the foreground and middleground. Usually from a minimim of 3 to 5 miles to a maximum of about 15 miles from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit

Basic elements	The four major elements (form, line, color, and texture) which determine how the character of a landscape is perceived.
Biface	A stone tool that has been flaked on two sides.
Brine	A saline or salty solution. A solution containing appreciable amounts of sodium chloride and other salts.
Candidate species	Classified as C1 or C2: C1 are those species for which USFWS has sufficient information to propose listing as threatened or endangered. C2 are those species for which additional information is necessary.
Caldera	A large depression at the top of a volcano caused by sinking when large amounts of molten rock erupt or withdraw.
Characteristic landscape	The established landscape within an area being viewed. The term does not necessarily mean a naturalistic character. It could refer to a farming community, a rural landscape, a primarily natural environment, or other landscape which has an identifiable character.
Clear cut	A timber-harvest practice in which nearly all standing trees in a given area, whether suitable for board/lumber production or not, are cut and harvested.
Condensate	The liquid (condensed) form of geothermal steam.
Contrast	The effect of a striking difference in the form, line, color or texture of the landscape features within the area being viewed.
Core hole	Area where subsurface rock has been drilled and removed to provide geologic, hydrologic, or temperature information necessary to determine suitable areas for geothermal production.
Crater	A depression in the earth that can be caused by a number of different events. A caldera is a large form of a crater.
Cultural modification	Any man-caused change in the land or water form or vegetation or the addition of a structure which creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape.
Development drilling	Drilling done in a geothermal reservoir to determine more precisely the size, grade, and configuration subsequent to the time the determination is made that the deposit can be commercially developed.
Distance zone	The area that can be seen as foreground, middleground, background or seldom seen. Areas of the landscape denoted by specified distances from the observer. The term is used as a frame of reference to discuss landscape characteristics or activities of man.

Endangered	Those species which are in danger of extinction within the foreseeable future throughout all or a significant part of their range.
Electric field	An energy field produced by voltage, measured in kilovolts per meter.
Exploration drilling	Drilling to locate a probable geothermal resource or to establish the nature of geologic structures; such wells may not be capable of production even if a geothermal reservoir is discovered.
Exploration well	A well initially drilled to find or test the capability of a geothermal reservoir to produce fluids, and, if successful, to produce fluids to supply a power plant.
Explosion breccia	Rock from an explosive volcanic eruption consisting of angular fragments embedded in a fine-grain matrix.
Fault escarpment	A fault line where vertical displacement of rock has taken place, forming a topographic feature such as a cliff face.
Foreground	The detailed landscape found within 0 to 0.4-0.8 km (0 to 1/4-1/2 mile) from the observer.
Fissure vent	The opening at the earth's surface of a volcanic conduit having the form of a crack or fissure.
Flash technology	Process whereby natural hot water is converted ("flashed") to steam which can then be used to run a turbine.
Forbs	An herb other than grasses.
Frost heave	Break up of soil layers through the action of freezing and thawing.
Fumarole	A vent, usually volcanic, from which gases and vapors issue.
Geothermal energy	Heat energy from inside the earth which may be residual heat, friction heat, or a result of radioactive decay. The heat is found in rocks and fluids at various depths and may be extracted by drilling and/or pumping.
Geothermal pilot project	BPA program to test the availability of geothermal energy as a potential alternative source of reliable and environmentally sound energy.
Groundwater	Water occurring in the subsurface zone where all spaces are filled with water under pressure greater than that of the atmosphere.
Guys	Generally, a rope, chain, rod or wire attached to something as a brace or guide.
Injection well	A well used to dispose of excess brine, steam condensate, and cooling tower water.

Intrusion	A feature (land or water form, vegetation, or structure) which is generally considered out of context because of excessive contrast and disharmony with the characteristic landscape.
Kilowatt	One thousand watts of electricity (see watt).
Landscape character	The arrangement of a particular landscape as formed by the variety and intensity of the landscape features and the four basic elements (form, line, color, and texture). These factors give the area a distinctive quality which distinguishes it from its imme
Landscape character type	Large physiographic area of land which has common characteristics of landforms, rock formations, water forms, and vegetative patterns.
Landscape character subtype	A division of a major character type which is significantly different in visual characteristics from the other subtypes.
Landscape features	The land and water forms, vegetation, and structures which compose the characteristic landscape.
Lapilli	Fragments thrown into the air by volcanic activity that are pea-size to lemon-size.
Lithic scatter	An archaeological site composed of residue from stone tool making and maintenance and/or tools and debris associated with other activities. These sites tend to be surface phenomena or contain shallow deposits.
Magnetic field	An energy field produced by the movement of electrons in a wire (current), measured in milligauss (mG).
Make-up water	The water that must be supplied to the condenser to replace water lost in the cooling tower. It will normally be supplied by condensed steam from the turbine.
Management indicator species	Wildlife species identified by the Deschutes National Forest used to determine management prescriptions for habitat types upon which these and associated species depend.
Maximum modification	A Visual Quality Objective meaning man's activity may dominate the characteristic landscape but should appear as a natural occurrence when viewed as background.
Megawatt (MW)	One million watts of electricity (see watt).
Middleground	The space between the foreground and the background in a picture or landscape. The area located from 1/4-1/2 to 3-5 miles from the viewer.
Milling stone	Stone generally used in the processing of seeds, roots or other vegetative matter.

Modification	A Visual Quality Objective meaning man's activity may dominate the characteristic landscape but must, at the same time, utilize naturally established form, line, color, and texture. It should appear as a natural occurrence when viewed in foreground or mid
No surface occupancy zone	A feature of NNVM legislation that prohibits surface occupancy by any development, but allows underground access that can be obtained by directional drilling.
Observer point	One or a series of observer positions on a travel route or at a use area, or a potential use area, used to determine seen area.
Observer position	The placement and relationship of a viewer to the landscape which is being perceived.
Obsidian	Volcanic glass of high silica content frequently used as raw material by prehistoric people for tool making.
Orthophoto	An aerial photograph that has been corrected to match actual topography and scale.
Partial retention	A Visual Quality Objective which in general means man's activities may be evident but must remain subordinate to the characteristic landscape.
Physiographic province	An extensive portion of the landscape, normally encompassing many hundreds of square miles, which has common qualities of soil, rock, slope, and vegetation of the same geomorphic origin.
Preservation	A Visual Quality Objective that provides for ecological change only.
Project area	Area encompassing CEE leases, alternative plant sites, well pads, gathering systems, transmission lines and access roads.
Project region	Area including project area, the entire NNVM, and north to Bend.
Project vicinity	Area including project area, and that portion of the NNVM west of project area west to Hwy. 97.
Projectile point	A chipped stone artifact used to tip an arrow (arrowhead) or dart.
Pumice	Volcanic glass foam, very light in weight and containing a high silica content.
RARE	Roadless Area Review Evaluation
Recreation Opportunity Spectrum (ROS)	This refers to a system used to identify and analyze broad categories of recreation opportunities and settings of forest lands. It involves a forest-wide recreation analysis of the physical setting (remoteness, size, and evidence of humans), social settin

- Establishing outdoor management goals and objectives for specific management areas

- Tradeoff analyses of available recreation opportunities as characteristic settings would be changed by other proposed resource management actions

- Monitoring outputs in terms of established standards for experience and opportunities settings

- Specific management objectives and standards for project plans

ROS allocations include:

Rural. Characterized by substantially modified natural environment. Resource modification and utilization practices are primarily to enhance specific recreation activities and to maintain vegetative cover and soil. Sights and sounds of humans are readily

Roaded Modified. Characterized by a setting that is heavily modified by human activity. Access is generally easy for highway vehicles. The setting is generally the result of intensive commodity production. There is no size criteria. Concentration of users

Roaded Natural. Characterized by predominantly natural-appearing environment with moderate evidence of the sights and sounds of humans. Such evidence usually harmonizes with the natural environment. Interaction among users may be low to moderate, but with

Semi-Primitive Motorized. Characterized by a predominantly natural or natural-appearing environment of moderate to large size. Concentration of users is low, but there is often evidence of other users. The area is managed in such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is permitted. Wildlife species present are mid-range between those tolerant of human presence and those not.

Semi-Primitive Nonmotorized. Characterized by a predominantly natural or natural-appearing environment of moderate to large size. Interaction among users is low, but there is often evidence of other users. The area is managed in such a way that minimum on-site controls may be present, but are subtle. Motorized use is not permitted. Large mammals that are not too tolerant of humans may be present.

Wild River. Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

	Scenic River. Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.
	Recreational River. Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversions in the past.
Renewable energy source	An energy source that is regenerative or virtually inexhaustible. Typical examples are wind, geothermal, and water power.
Retention	A Visual Quality Objective which in general means man's activities are not evident to the casual forest visitor.
Ring fracture	A circular or arcuate fault associated with caldera-sinking.
Riparian	Relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or tidewater.
Rhyolite	Glassy- to fine-grained igneous rock with a high silica content (generally 70 percent or more).
Scenic area	An area whose landscape character has a high degree of a variety, harmony, and contrast among the basic visual elements which result in a landscape pleasant to view.
Scenic quality	The degree of harmony, contrast, and variety within a landscape.
Seen area	That portion of the landscape which can be viewed from one of more observer positions. The extent or area that can be viewed is normally limited by landform, vegetation, or distance.
Sensitivity	As applied to visual resource management, that degree of concern expressed by the user toward scenic quality and present or proposed visual change in a particular characteristic landscape.
Seismic activity (Seismicity)	The likelihood of an area being subject to earthquakes. The phenomenon of earth movements.
Sensitive species	Wildlife and plant species which have been either Federally- or State-recognized as deserving attention or protection due to either a suspected or confirmed decline in population or available/suitable habitat.
Soil liquefaction	Any process which causes soil to behave as a liquid.
Special management area	A feature of NNVM legislation that prohibits surface occupancy by any development, but allows underground access that can be obtained by directional drilling.

Study area	That portion of the project area, project vicinity, and project region which was used to investigate existing conditions and possible impacts. The study area differs by resource.
Subsidence	The downward settling, or sinking of a portion of the ground's surface relative to its immediate surroundings.
Sump	Small pits used to hold left-over fluids from wells.
Switch yard	An interconnection point between two power lines where automatic relay and manual isolation switches are located, which, when opened, break the electrical relay between the two transmission lines.
Temperature gradient well	A small-diameter well drilled to gather subsurface temperature information that will be used along with geologic information to determine the most likely areas for geothermal energy production. These wells would be drilled up to 1,676 meters (5,500 feet).
Thermal convection	Circulatory motion that occurs in a fluid in a non-uniform temperature owing to the variation of its density and the action of gravity.
Threatened	Those species likely to become endangered within the foreseeable future.
Transmission	The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is
Turbine	A machine for generating rotary mechanical power from the energy in a stream of fluid (such as water, steam, or hot gas), converting the kinetic energy of the fluid to mechanical energy.
Underbuild	A second string of conductors, underneath the 115-kV conductors, that transmits electricity at a lower voltage.
Upset	A rapid, unscheduled plant shutdown, usually caused by mechanical problems or equipment failure in the power plant, or by a transmission outage.
Use volume	The total volume of visitor use each segment of a travel route or use area receives.
Variety class	The value (A, B, or C) assigned to a scenic quality rating unit by applying the scenic quality evaluation key factors which indicate the relative visual importance of the unit to the other units within the same physiographic region.
View	Something, especially a broad landscape or panorama, that is looked toward or remains in sight. The act of looking toward this object or scene.

Visual absorption capability	The relative ability of a landscape to withstand land manipulation activities without affecting its visual character or integrity.
Visual Management System (VMS)	The planning, design, and implementation of management objectives to provide acceptable levels of visual impacts for all USFS resource management activities.
Visual Quality Objective (VQO)	Indicates the degree of visual change that is acceptable within the characteristic landscape. It is based on the physical and sociological characteristics of any given homogeneous area and services as a management objective.
Visual quality standards	Measurements or criterion by which visual and aesthetic resources are managed by the U.S. Forest Service.
Visual resource	The land, water, vegetative, animal, and other features that are visible on all lands (scenic values).
Visual sensitivity level(s)	An index of the relative degree of user interest in scenic quality and concern and attitude toward present or proposed changes in the landscape features of an area in relation to other areas in the planning unit.
Watershed	A region or area bounded peripherally by water parting and draining ultimately to a particular water course or body of water.
Watt (Electric)	The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.
Wheeling	The use of the transmission facilities of one system to transmit power and energy by agreement of, and or, for another system with corresponding wheeling charge (e.g., the transmission of electricity for compensation over a system that is received from on

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