Newberry Volcano Enhanced Geothermal System (EGS) Demonstration Project

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT (BLM)

DOI-BLM-OR-P000-2011-0003-EA
DOE/EA-1897

ENVIRONMENTAL ASSESSMENT DECEMBER 2011

Location:	Federal Geothermal Leases on the West Flank of Newberry Volcano, Deschutes County, 22 miles south of Bend, Oregon
Applicant:	Davenport Newberry Holdings LLC and AltaRock Energy, Inc. 225 NW Franklin Avenue, Suite 1 Bend, OR 97701 Tel: 541-323-1190
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Cooperating Agencies:	U.S. Department of Agriculture, Forest Service Deschutes National Forest, Bend-Fort Rock Ranger District 63095 Deschutes Market Rd. Bend, OR 97701 Tel: 541-383-4000; FAX 541-383-4700 U.S. Department of Energy, Golden Field Office 1617 Cole Boulevard Golden, CO 80401 Tel: 720-356-1563; Fax: 720-356-1560

CONTENTS

Note: The appendices attached to this PDF document are available online at

http://www.blm.gov/or/districts/prineville/plans/newberryegs/index.php

or by contacting the BLM Prinveville District Office.

TABLE OF FIGURES

List of Acronyms and Glossary of Terms

API	American Petroleum Institute
ASL	Above sea level
BE	Biological Evaluation
bgs	below ground surface
BH	Borehole
BLM	Bureau of Land Management
CE	CalEnergy
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMP	Comprehensive Management Plan
csg	Casing
DOE	Department of Energy
DOGAMI	Department of Geology and Mineral Industries
DOI	Department of Interior
DR	Decision Record
DRC	Deschutes River Conservancy
EA	Environmental Assessment
EGS	Enhanced / Engineered Geothermal Systems
EIS	Environmental Impact Statement
ESC	Existing Scenic Condition
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FLPMA	Federal Land Management and Policy Act
Flashing	Sudden lowering of the pressure of hot water, thus allowing boiling
FONSI	Finding of No Significant Impact
FR	Forest Road
FS	Forest Service
GL	Ground level
gpm	Gallons per minute
GPS	Global Positioning System
HP	Horsepower
IEA	International Energy Agency

ISMP	Induced Seismicity Mitigation Plan
KB	Kelly bushing
kW	Kilowatt
LBNL	Lawrence Berkeley National Lab
LiDAR	Light Detection and Ranging
LLC	Limited Liability Company
LPHS	La Pine High School
LRMP	Land and Resource Management Plan
M	Magnitude (seismicity)
Mmax	Maximum Magnitude
MA	Management Area
MIS	Management Indicator Species
MM	Modified Mercalli
MSA	Microseismic array
Microseismometer	An instrument used to measure micrsoseismic events. Micro refers to the ability of the instrument to measure micro seismic events, not the physical size of the instrument itself.
MSDS	Material Safety Data Sheet
MW	Megawatt
NAIP	National Agriculture Imagery Program
NEPA	National Environmental Policy Act
NGC	Newberry Geothermal Company
NM	Surface Microseismic Station
NN	Borehole Microseismic Station
NNVM	Newberry National Volcanic Monument
NWG	Northwest Geothermal
O&G	Oil and Gas
OHV	Off-highway vehicle
OWRD	Oregon Water Resources Department
PEIS	Preliminary Environmental Impact Statement
PGA	Peak ground acceleration
PLA	Polymer of lactic acid
PLVC	Paulina Lake Visitor Center
PNSN	Pacific Northwest Seismic Network
POO	Plan of Operations
PR	Partial Retention

PSHA	Probabilistic seismic hazard analysis
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PVC	Polyvinyl chloride
PW	Production well
RF	Rossi-Forel
RM	River mile
RMHA	River Meadows Homeowners Association
S&G	Standards and Guidelines
SCL	Scenic Condition Level
Seismic Risk	The probability of loss or damage due to seismicity
SMS	Scenery Management System (Scenic Resources)
SMS	Strong Motion Sensor
SPE	Society of Petroleum Engineers
T&R	Treadwell & Rollo Engineers
TD	Total depth
TG	Temperature gradient
TGH	Temperature Gradient Hole
TM	Trademark
TVD	True vertical depth
U.S.C.	United States Code
URS	United Research Services
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VAC	Visual Absorption Capability
VOP	Visual observation point
VQS	Visual Quality System

CHAPTER 1. INTRODUCTION AND PURPOSE & NEED FOR THE PROPOSED ACTION

1.1 INTRODUCTION

This Environmental Assessment has been prepared to disclose and analyze environmental effects of developing and testing a geothermal reservoir created by using enhanced geothermal system (EGS) technologies, as proposed by Davenport Newberry Holdings LLC (Davenport) and AltaRock Energy, Inc. (AltaRock). A Notice of Intent (NOI) and "Plan of Exploration, Operations Plan, and Drilling Program for the Newberry Volcano EGS Demonstration Project" (Project, EGS Project) were submitted to the Prineville Office of the Bureau of Land Management (BLM) in May, 2010.

The proposed Project is located in central Oregon on Deschutes National Forest lands along the western flank of Newberry Volcano. Except for some seismic monitoring stations (Figure 2 and described in Section 2.3), the Project is located outside the Newberry National Volcanic Monument (Monument or NNVM), on federal geothermal leases administered by the BLM that were issued between 1982 and 2003. Davenport Newberry LLC is currently the holder of all geothermal leases identified in the NOI.

The BLM is the lead agency for this project because the majority of the Project activity would occur on leases issued and administered by the BLM. The proposed Project is located entirely on National Forest system lands as part of the USDA Forest Service, Deschutes National Forest (Forest Service or FS). Nine (9) of the monitoring stations necessary to implement the Seismic Mitigation Plan are within lands where surface disturbance is under the authority of the Forest Service. Therefore the Forest Service is a cooperating agency for the preparation of this Environmental Assessment. The Energy Policy Act of 2005 gives the Secretary of Energy the authority to conduct a program of research, development, demonstration, and commercial application for geothermal energy. The U.S. Department of Energy (DOE) is funding a portion of the Project; therefore DOE is also a cooperating agency in this EA.

1.2 SUMMARY OF THE PROPOSED ACTION

Davenport and AltaRock (Proponents) propose to create an EGS Demonstration Project involving new technology, techniques, and advanced monitoring protocols for the purpose of testing the feasibility and viability of enhanced geothermal systems for renewable energy production.

The Project would utilize an existing well pad and existing deep geothermal well on federal geothermal lease OR40497 held by Davenport Newberry Holdings LLC. Nearby there would be 20 microseismic monitoring stations. All of these sites are on national forest system lands. Eleven of the sites would be on federal geothermal leases administered by the BLM, and 9 would be on lands that are administered by USFS (Table 1). If approved, drilling and installation of the downhole microseismic monitoring stations for the Project would begin in early 2012.

Table 1: MSA Locations and Surface Management Authority

MSA Site	Type	Section	NEPA Decision Authority for Surface Management
NN19	New Borehole	29	BLM
NN24	New Borehole	29	BLM
NN21	Pre-Existing Well	21	FS
TG19	Pre-Existing Well	19	BLM
NN18	Pre-Existing Well	21	FS
NN17	New Borehole	29	BLM
TG32	Existing Well	32	BLM
NP03	Existing Well	6	BLM
TG17	Existing Well	17	BLM
TG30	Existing Well	30	BLM
NM08	Surface Station	4	FS
NM22	Surface Station	29	BLM
NM03	Surface Station	16	BLM
NM05	Surface Station	21	FS
NM06	Surface Station	28	FS
NM18	Surface Station	21	FS
NM40	Surface Station	27	FS
NM42	Surface Station	15	FS
NM41	Surface Station	33	FS
NM11	Surface Station	36	BLM

The proposed project area is located approximately 22 miles south of Bend and 10 miles northeast of La Pine, within the Bend-Fort Rock Ranger District of the Deschutes National Forest. Refer to Figure 1, Project Vicinity Map. The Project is located in an area of the Deschutes National Forest identified as appropriate for future geothermal exploration in the 1990 Deschutes National Forest Land and Resource Management Plan (LRMP), as amended. This area was also recognized as being appropriate for geothermal use in the congressional process and subsequent federal legislation that created the Newberry National Volcanic Monument (Newberry National Volcanic Monument Act (Public Law 101-522), November 1990).

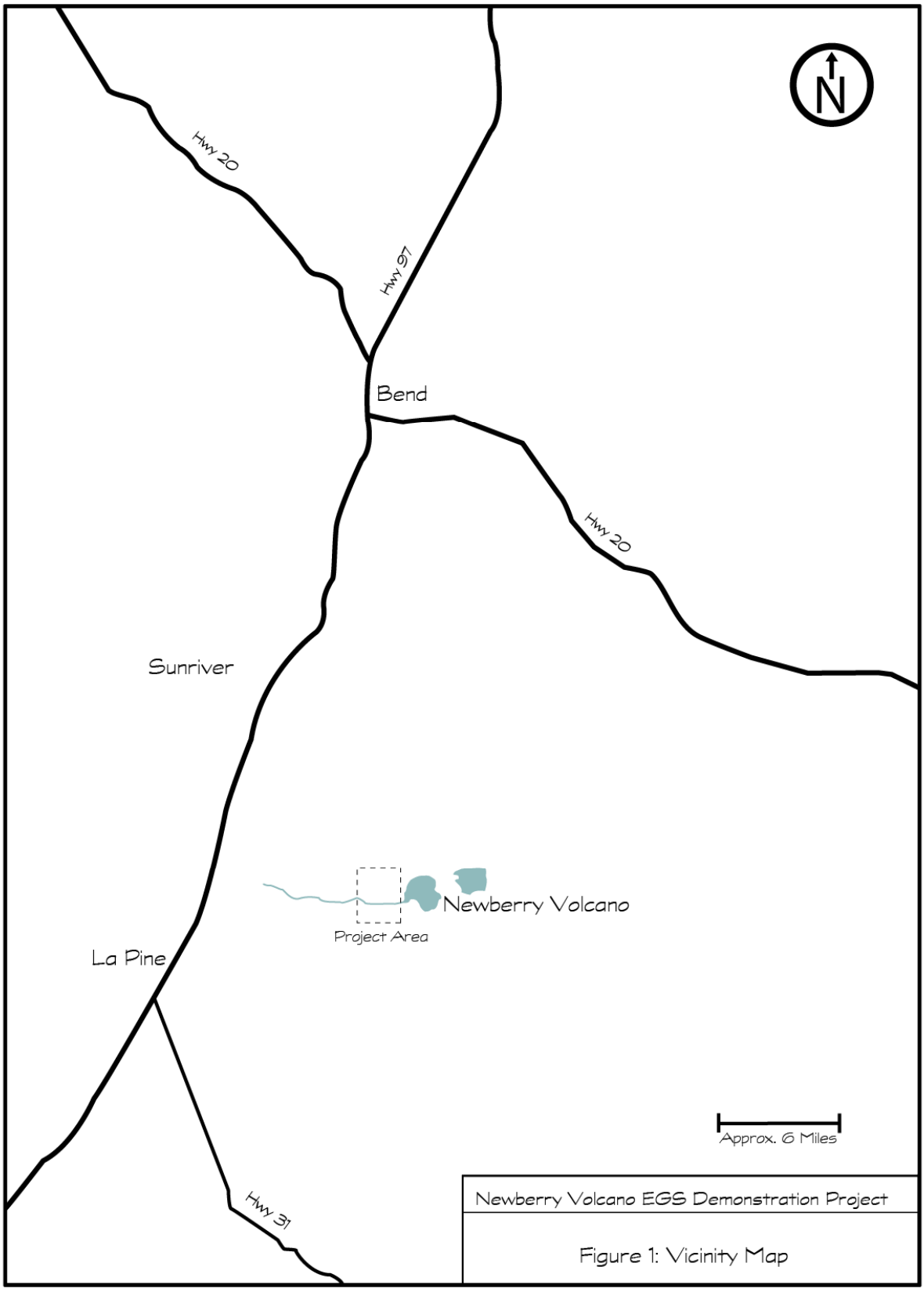

Figure 1: Project Vicinity Map

Creation of the Reservoir

The proposed Project would develop and test an EGS reservoir deep underground, using an existing 10,060-foot geothermal well (NWG 55-29/Well 55-29). This well pad (S-29) was built and the well drilled by Davenport in 2008. Data from Well 55-29 shows that this site has a great deal of heat in the deep underground rock formations (> 600 º F) but it does not have sufficient natural water for a standard hydrothermal geothermal system. Sites such as this may be suitable for EGS, where water can be added to naturally occurring hot rock in order to create a viable geothermal system.

Creation of the EGS involves engineering a "reservoir" in suitable hot rocks where water can circulate through and heat up, much like the heat exchange process of a radiator. The reservoir is created by using a process of well stimulation termed "hydroshearing." Hydroshearing is the process of using cold water to create a network of minute cracks in the rocks deep underground, where natural fractures and cracks already occur. During this process, water would be injected at high pressure (estimated to range between 1,160 and 2,600 psig) at the bottom of Well 55-29, at depths of approximately 6,500 to 10,000 feet. Shallow groundwater wells would provide the water for the Project.

The Project goal is to create a network of pore spaces from the injected high pressure water in a finite area of the hot rock formation that would then serve as a heat exchanger and become the EGS reservoir. Cold water would be pumped from the surface down the existing well into the reservoir, where it would become heated as it circulates through the hot rocks and then be brought back up to the surface as hot water, via two production wells.

After the reservoir has been created, two additional deep geothermal production wells would be directionally drilled from the same well pad into the "other end" of the EGS reservoir. The heated water would be brought back up to the surface in these wells, after it has circulated through the network of pores and cracks of the hot rocks between the wells. This Project would provide the Proponents the ability to create, test, and demonstrate the EGS reservoir technology and its potential application to produce electricity in areas with underground heat but no natural water.

This Project is for EGS reservoir demonstration purposes only; production of electricity is not being proposed and is not part of this Project. If an EGS reservoir were developed to produce electricity however, the hot water and/or steam brought to the surface would be used to provide energy to turn turbines and generate electricity— in a similar manner that natural hydrothermal geothermal systems are currently used to generate electricity in the U.S. and around the world. If a power plant were proposed it would require further NEPA analysis.

Monitoring the Stimulation Process

Minute fractures created by the injection of high pressure water during the hydroshearing process would cause microseismic events which would be mapped and monitored using state-of-the-art equipment and technology. Monitoring and mapping of the micro fractures would be accomplished through an array using small pieces of microseismic monitoring equipment (microseismometers) installed either a few feet

below ground (surface stations), or in nearby boreholes (borehole stations) drilled to a depth of up to 1,100 feet. Of the 20 monitoring sites, 10 locations would be surface stations and 10 locations would be borehole stations. The equipment would be strategically and carefully located in an array designed to effectively receive the scientific data.

This "microseismic array" (MSA) would monitor microseismic events and the creation of the minute cracks in real time. Of the 10 borehole MSA locations, 3 new boreholes would be drilled (Sites NN17, NN19 and NN24 shown in Figure 2), using a truck-mounted rotary drilling rig similar to those used to drill domestic water wells. Existing well sites (temperature gradient wells, water wells and geothermal exploration wells) would be utilized to the extent possible to minimize new surface disturbance, as a result 7 of the 10 proposed borehole MSA sites would be located in existing wells or at sites already approved for such wells.

Site footprints for each of the new MSA boreholes would average approximately 75 ft. x 125 ft. (9,375 sq. ft., or 0.2 acre) in size to safely accommodate equipment, including a drill rig and water truck. Total surface disturbance for all 3 new borehole stations would be approximately 28,125 square feet, (2/3 acres) total. All proposed sites are accessible from existing Forest Service roads and no new roads would be constructed.

All of the 10 surface MSA sites would be located in areas that would not require tree removal. For these sites, the microseismometers would be placed in shallow holes dug a few feet deep using hand tools.

Once the underground EGS reservoir is created and the 2 new production wells have been drilled, a circulation test of approximately 30 to 60 days would be conducted in order to test the circulating system and collect scientific data. This data would be used to create a detailed conceptual model of a hypothetical EGS reservoir, well field, and power plant that could potentially be used to plan EGS projects in this area and other areas of the United States. The decision whether to allow this EGS Project does not allow for the production of electricity and no facilities capable of generating electric power are being proposed. Further analysis under NEPA would be required prior to a decision to develop an electric production facility at Newberry.

The Project would be conducted over a total time period of approximately 2 years. During this time, there would be relatively constant on-going project-related activities including clearing, installation, drilling, and flow testing activities on one or more sites. Activities would be concentrated around the existing pad S-29.

1.3 Background

Geothermal energy is renewable energy derived from the heat stored in the earth, typically circulated by water within zones of naturally occurring fractured rock formations deep underground. At high enough temperatures the naturally occurring hot water and/or steam can be brought to the surface and harnessed to generate electricity. After the heat is removed, the condensed steam/geothermal fluids are then recirculated back underground. This is the way in which a typical hydrothermal geothermal energy system functions.

Newberry Volcano has long been recognized by geologic and scientific communities for its geothermal potential, and a number of exploration operations in search of a viable geothermal resource have occurred in the area over the last three decades. Nearly two dozen exploratory wells have been drilled at depths from about 1,300 feet to nearly 12,000 feet in areas on the west flank, including 2 exploration wells drilled to 10,060 and 11,600 feet by Davenport in 2008.

Exploration activities and scientific studies at Newberry have verified that certain rock formations deep underground indeed contain sufficient heat, and in some cases there have been indications of the presence of water. However, the unique characteristics of the geothermal resource in this area have yet to be fully depicted or understood, and a viable natural hydrothermal system has yet to be discovered. The proposed demonstration project seeks to further explore the potential of new enhanced geothermal technology that could potentially utilize the naturally occurring heat in suitable underground rock formations that lack a naturally existing water component and permeability.

1.4 Purpose and Need for the Proposed Action

BLM

The purpose of the proposed action is to grant, grant with modifications, or deny the Proponents' proposal to use National Forest lands, including National Forest lands with and without geothermal leases that have been issued and are administered by the BLM, to develop and test an EGS demonstration facility in compliance with BLM geothermal leasing regulations, and other applicable Federal laws. The proposed action would assist the BLM in meeting the management objectives in the Energy Policy Act of 2005 (Title II, Section 211), which establish a goal for the Secretary of the Interior to approve 10,000 MWs of electricity from non-hydropower renewable energy projects located on public lands. The proposed action also would further the purpose of Secretarial Order 3285 (March 11, 2009) that established the development of environmentally responsible renewable energy as a priority for the Department of the Interior.

The need for the proposed action is for BLM to respond to a Notice of Intent and "Plan of Exploration, Operations Plan, and Drilling Program for the Newberry Volcano EGS Demonstration Project" (Project, EGS Project) submitted by the Proponents to develop and test EGS demonstration technology and associated monitoring equipment on National Forest lands. These lands include National Forest lands with and without geothermal leases that have been issued and are administered by the BLM. In accordance with The Geothermal Steam Act ((Geothermal Steam Act of 1970 (30 U.S.C. 1001-1025) and 43 CFR subpart 3207)), BLM must respond to requests by lessees to explore geothermal resources in accordance to lease stipulations on federal geothermal leases.

FS

As a cooperating agency, the purpose of the proposed action as to the Forest Service is to assist BLM in deciding whether to grant, grant with modifications, or deny the Proponents' proposal to use public lands managed by the BLM to develop and test an

EGS demonstration facility in compliance with applicable geothermal leasing regulations and other Federal laws. A secondary purpose is for the Forest Service to carry out federal energy policy, orders, and objectives, including those from:

- The National Energy Policy (May 2001) which includes the need "to expedite projects that will increase the production, transmission, or conservation of energy" (Section 1, Policy and Executive Order 13212), and
- The Energy Policy Act of 2005 (Public Law 109-58) for promoting the leasing and development of geothermal resources where appropriate on public lands.

As the manager of the national forest lands on which the EGS Project is proposed, Forest Service has a need to cooperate with BLM as it evaluates projects on geothermal leases that were issued with Forest Service consent. Forest Service also has a need to ensure that the proposed EGS Project meets the goals, objectives, standards and guidelines of the 1990 LRMP for the Deschutes National Forest, and the Newberry National Volcanic Monument Plan.

This project has MSA stations being proposed where the Forest Service has the decision authority under NEPA and as a result the Forest Service has a need to make a decision to issue or not issue a permit for these stations.

DOE

The National Environmental Policy Act (42 U.S.C. 4341 *et seq*.; NEPA), the Council on Environmental Quality's NEPA regulations (40 Code of Federal Regulations [CFR] Parts 1500 to 1508), and the DOE's NEPA implementing procedures (10 CFR Part 1021) require that DOE consider the potential environmental impacts of a proposed action before making a decision. This requirement applies to decisions about whether to provide different types of financial assistance to private entities.

As background, in an effort to increase national energy options, reduce vulnerability to disruption and increase the flexibility of the market to meet U.S. needs, DOE's Geothermal Technologies Program (GTP) facilitates research, development, and demonstration to establish geothermal energy as a major contributor for electricity generation. One way to accomplish this is to extract heat from hot, underground rock, an indigenous resource, and convert the heat to electricity. Enhanced Geothermal Systems (EGS) are engineered reservoirs created to produce energy from geothermal resources deficient in water and/or permeability.

With regard to EGS, DOE is seeking to address key aspects of site selection and characterization, reservoir creation and validation, reservoir sustainability, and plant operation and management through advanced technologies. As part of the American Recovery and Reinvestment Act of 2009, DOE issued a funding opportunity announcement DE-PE36-09GO99019 Enhanced Geothermal Systems Demonstrations through which DOE sought to fund projects in a variety of geologic formations that could quantitatively demonstrate and validate stimulation techniques that successfully sustain sufficient fluid flow and heat extraction rates for 5-7 years that produce up to 50 MWe per year per project site/geothermal reservoir. The proposed EGS Project has the potential to advance EGS technology by developing and testing an EGS reservoir. DOE is

proposing to authorize the expenditure of federal funding through the GTP to AltaRock for the proposed EGS Project. DOE has already authorized the use of a small percentage of the Federal funding for preliminary activities and associated analyses.

1.5 Management Direction and Conformance with Land Use Plans

The proposed Project is located on federal lands managed by the Forest Service. Land Management Plans (Deschutes National Forest LRMP (1990) and Newberry National Volcanic Monument Plan (1994)) have been completed for all lands upon which activities are proposed, both lands leased for geothermal exploration and unleased lands. In accordance with the National Forest Management Act (NFMA) and the Newberry National Volcanic Monument Act, all activities on National Forest lands must be consistent with the applicable management plans.

In accordance with the Federal Land Policy and Management Act (FLPMA) of 1976, as amended, for leased lands, BLM regulations require that activity on geothermal and other leases conform with the Deschutes National Forest LRMP. The Deschutes National Forest LRMP provides statutory guidance for all Forest management activities including the potential for geothermal exploration and development.

Forest management goals reflect a vision for all Forest resources including a goal to "provide for exploration, development, and production of energy resources on the Forest while maintaining compatibility with other resource values." (LRMP p. 4-2).

According to the LRMP, the desired future condition for energy resources predicts the potential importance of the geothermal resource and states, "Large areas of the Forest have become prime targets for the exploration and development of geothermal energy. If the supply of electricity in the western states slips from surplus to deficit, geothermal energy development will become increasingly attractive." (LRMP p. 4-6). Further anticipating geothermal exploration and development, the desired future condition also explains that "geothermal leases and permits have been issued in a timely way. 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." (LRMP p. 4-6).

Standards and guidelines (S&G's) in the LRMP provide more detailed direction to help mitigate effects, minimize conflicts, and protect resource values. Forest-wide standards and guidelines provide overall Forest direction and affirm, among other things, that "the notices and stipulations in leases issued prior to implementation of this Plan take precedent over standards/guidelines developed in this Plan. These existing leases will continue and have prior rights. Proposals to explore develop, and produce electricity on all leases, past and future will be evaluated through the NEPA process. To the extent possible, consistent with existing lease rights, standards/guidelines will be followed." (LRMP p. 4-77)

Geothermal operations are guided by which management area (MA) they are located in and the S&Gs that apply to that particular MA. The proposed Project falls within two MAs, "general forest" and "scenic views." Both MAs allow for geothermal uses. The goal for general forest (MA-8) is to emphasize timber production, and the goal for scenic

views (MA-9) is to provide Forest visitors with high quality scenery. The S&Gs that address geothermal and mineral activities for each MA are:

- General Forest—S&G M8-17. "Geothermal leases will be issued. Conditional Surface Use and Seasonal Restrictions Stipulations will be used to protect wildlife habitat and recreation areas that are included in the General Forest Area."
- Scenic Views—S&G M9-83. "Mineral developments, utilities, and electronic sites may be located in these areas if the 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 usual large scale of these facilities. However, when viewed from travel routes, recreation areas, and other sensitive viewer locations, Visual Quality Objectives should be met."
- Scenic Views—S&G M9-84. "Trees may be removed within the Scenic Views Management Area where necessary to permit access to geothermal sites, mineral development, electronic sites, utilities, and other special use sites.

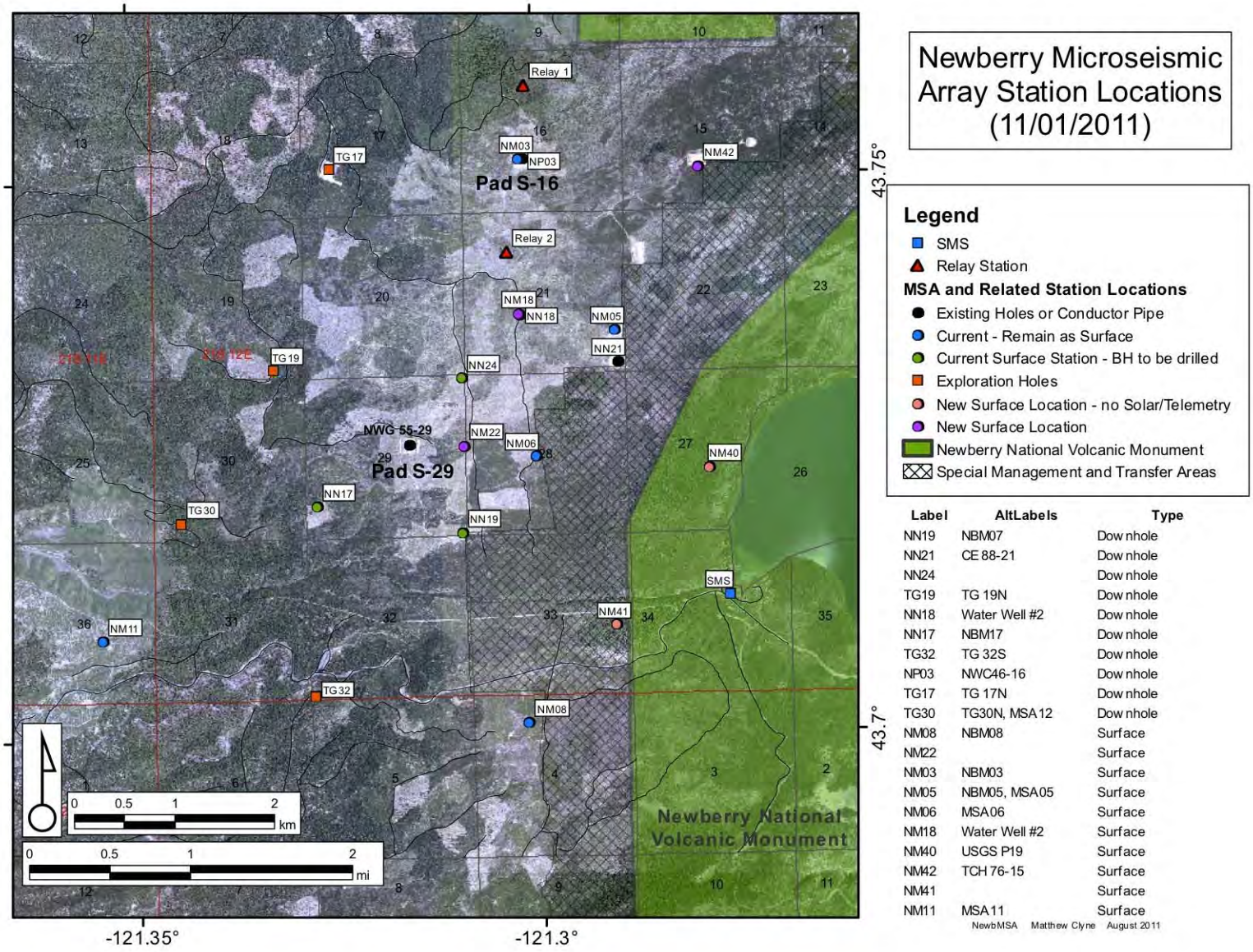

Figure 2: Detailed Project Location Map

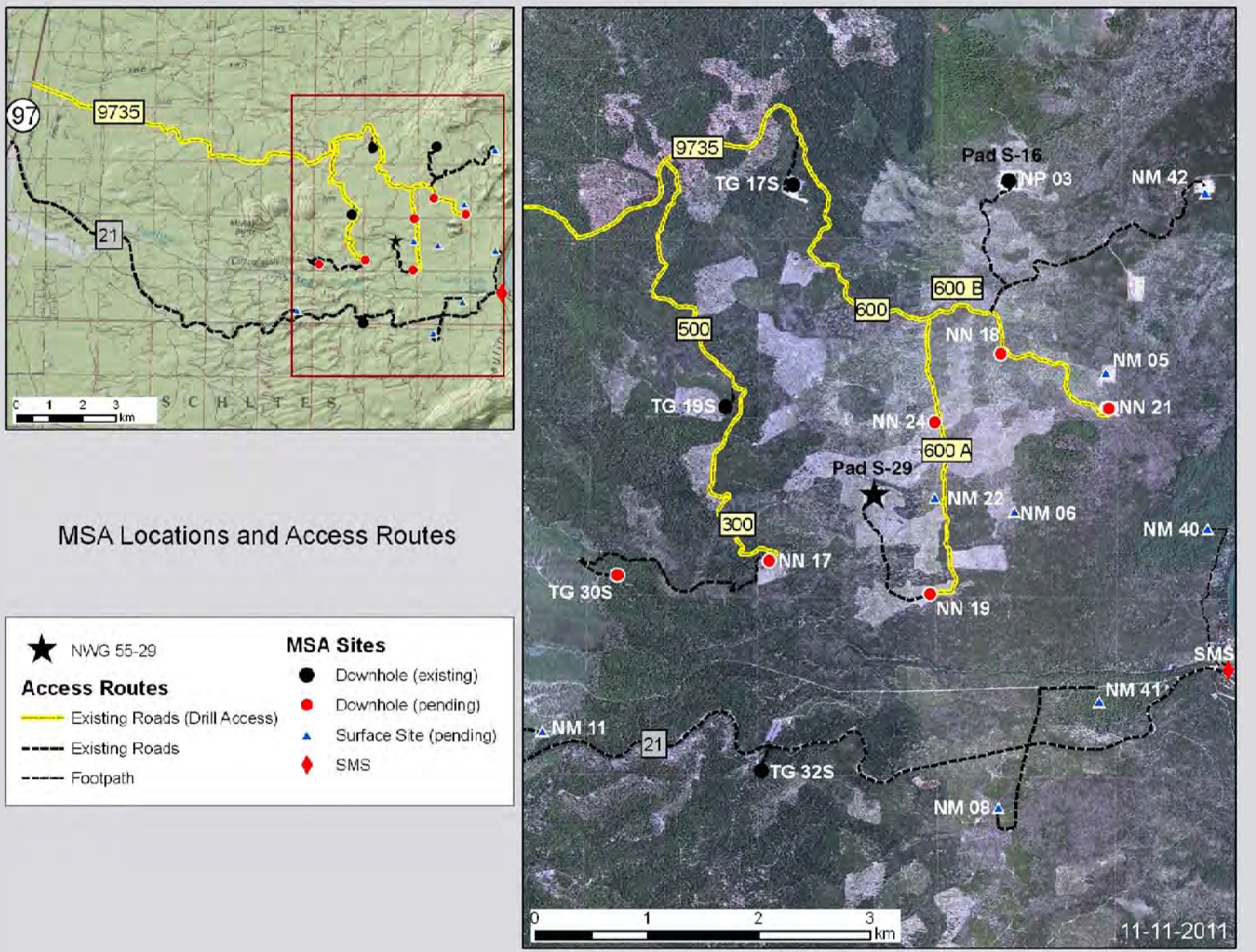

Figure 3: Project Access Routes

1.6 Relationship to Laws, Regulations, Policies, and NEPA Documents

- **Newberry National Volcanic Monument Act (Public Law 101-522), November 1990.**

  In 1990, Congress designated over 50,000 acres to become the Newberry National Volcanic Monument through the Newberry National Volcanic Monument Act (Monument Act). The Act creating the Monument restricts geothermal development within the NNVM and also provides specific guidance related to activities outside the Monument boundaries.

  "Nothing in this Act shall be construed as authorizing or directing the establishment of protective perimeters or buffer zones around the Monument or Special Management Area for the purpose of precluding activities outside the Monument and Special Management Area boundary which would otherwise be permitted under applicable law….The fact that activities or uses outside the Monument and Special Management Area can be seen, heard, measured, or otherwise perceived from within the Monument and Special Management Area shall not, of themselves, limit, restrict, or preclude such activities or uses up to the boundary of the Monument and the Special Management Area" (Public Law 101-522, Section 8(a)).

  In addition, the Act includes a provision for: "The Secretary, in cooperation with the Secretary of Interior, shall maintain a research and monitoring program for geothermal resources for the purpose of identifying and assessing the impact that present and proposed geothermal development in the vicinity of the Monument and Special Mangement Area may have on the values for which such Monument and Special Management Area were established" (Sec. 6(b)(7)).

- **Newberry National Volcanic Monument Comprehensive Management Plan, August 1994.**

  As mandated in the Monument Act, the Forest Service prepared a Comprehensive Management Plan (CMP) for the NNVM establishing programmatic management direction for National Forest lands within the newly created Monument and for the four specially designated areas (Special Management Area, Transferal Area Adjacent, Transferal Area, and Transferal Corridor) within the Monument boundary that may be used for geothermal exploration and development under certain circumstances.

  Consistent with the Monument Act, the CMP acknowledges there are valid geothermal leases within the Special Areas identified within the Monument Act. The CMP includes a goal "to manage the surface of the Special Management Area and of the Transferal Area Adjacent as part of the Monument, while allowing subsurface exploration for and development of geothermal resources" (CMP, page 7).

- **The Federal Land Policy and Management Act of 1976 ("FLPMA"), as Amended, October 2001 (Public Law 94-579).**

  Among other things, FLPMA establishes public land policy; establishes guidelines for its administration; and provides for the management, protection, development, and

enhancement of the public lands. FLPMA also establishes the BLM's multiple-use mandate to serve present and future generations and directs that on BLM leases the management plan in place be used for guidance.

- The National Forest Management Act of 1976 ("NFMA"), as Amended, 1990 (Public Law 94-588)

  NFMA requires that all National Forests develop Land and Resource Management Plans to guide allowable uses and activities on National Forest System Lands, and that all activities be consistent with those plans.

- Programmatic Environmental Impact Statement for Geothermal Leasing in the Western US, December 2008.

  One of the goals of the Programmatic Environmental Impact Statement (PEIS) is to facilitate geothermal leasing decisions in the western US. The PEIS was jointly prepared by BLM and Forest Service in cooperation with DOE, and includes a comprehensive list of stipulations, best management practices, and procedures to provide consistent guidance for geothermal exploration and development. This EA is consistent with the PEIS, and incorporates by reference effects analyzed and addressed in the PEIS and Record of Decision.

- National Energy Policy (May 2001) and Executive Order 13212–Actions to Expedite Energy-Related Projects.

  The above referenced Policy and Executive Order apply to energy-related projects and direct the federal agencies "to expedite projects that will increase the production, transmission, or conservation of energy", and "expedite their review of permits or take other action as necessary to accelerate the completion of such projects"[1].

- Energy Policy Act of 2005 (Public Law 109-58).

  This Act also applies to BLM and Forest Service and directs the agencies to promote leasing and development of geothermal resources where appropriate on public lands.

- Geothermal Steam Act of 1970 (Public Law 91-581).

  Under the terms of the Geothermal Steam Act and implementing regulations, BLM is required to respond to proposed geothermal plans, applications, and programs submitted by a lessee or the lessee's designated operator.

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[1] FR Vol. 66, No.99, Executive Order 13212 of May 18, 2001, Actions to Expedite Energy-Related Projects, Section 1 and 2, P. 28357

- National Environmental Policy Act of 1969, Council of Environmental Quality Regulations, and the Federal Land Policy and Management Act of 1976.

  This EA is prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), the Council of Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [CFR] 1500-1508) implementing NEPA, and the Federal Land Policy and Management Act (FLPMA) of 1976. Furthermore, this EA has been prepared in accordance with the BLM NEPA Handbook H-1790-1, January 2008.

- 994 Newberry Geothermal Pilot Project Final EIS and Record of Decision.

  In 1994 the Deschutes National Forest, Prineville District BLM, and Bonneville Power Administration analyzed potential effects of a proposed federal pilot project for geothermal exploration, development, and production of electrical energy on federal leases at Newberry, near the EGS project area. The pilot project was approved by Forest Service (as lead agency with BLM and Bonneville Power Administration as cooperating agencies) and several exploration wells were drilled, but the results were inconclusive and the project was suspended in 1996. An extensive and detailed environmental analysis was conducted for that project and some of the data may be relevant to the analysis of the proposed EGS Project; therefore, this NEPA document, and the two listed below, may be cited throughout this document where appropriate and are available at the Prineville District office.

- 2007 Newberry Geothermal Exploration Project EA and Decision Record (OR-050-075).

  The 2007 EA and Decision Record issued by BLM are incorporated by reference in this EA. The 2007 EA analyzed a Davenport Newberry exploration project that involves drilling deep geothermal exploration wells (10,000 feet deep or more) on three well pads each approximately 5 acres in size. All well pads were constructed and two wells have been drilled and continue to be monitored and evaluated. One well pad and well from this project (NWG 55-29) would be used for the proposed Project.

- 2010 EA and Decision Record for Drilling, Testing, and Monitoring of up to 12 Temperature Gradient / Passive Seismic Geothermal Exploratory Wells (DOI-BLM-OR-P000-2010-003-EA). (Davenport TG Program)

  This EA and subsequent Decision Record issued by BLM and the Finding of No Significant Impacts issued by DOE are also incorporated by reference. This 2010 EA analyzed twelve sites for shallow small diameter wells on ¼-acre well pad sites, to be used to collect geologic and seismic data to provide new information about the geology and potential geothermal resource in the area. Seven pads were prepared since 2010 and 7 wells were drilled; the project will continue in 2012. Up to four of the 10 borehole MSA stations proposed for the EGS Project would be located at well sites previously analyzed and approved in this EA, therefore these NEPA documents may be cited and also incorporated by reference.

1.7 Scoping and Public Involvement

On October 21, 2010 BLM mailed a Scoping Notice to 462 individuals, organizations, and agencies. Mailing lists from Prineville BLM, Deschutes National Forest, and Davenport were combined to ensure obtaining the widest coverage of people who are known to be interested in, or who may be interested in EGS technology and the proposed Newberry EGS Project.

Several public meetings were held to provide information about the proposed Project at Newberry in order to inform and engage the broadest possible central Oregon audience. AltaRock and Davenport made presentations, answered questions, and engaged the audience in discussion at each of the meetings.

On July 15, 2010 a meeting was held in La Pine and was attended by 21 people, and more than a dozen people attended a similar meeting in Sunriver on August 12, 2010. A public meeting was also held in Bend on September 21, 2010 and attended by approximately 26 people. Representatives from BLM, Forest Service, and DOE participated, AltaRock and Davenport made presentations, and audience interaction and questions were encouraged. Various central Oregon media representatives were at all three public meetings. The BLM with the Forest Service and the proponents led a field tour during the public scoping period on November 10, 2010, with 25 members of the public participating.

In the local media, there were at least 23 articles and notices published about EGS, geothermal exploration at Newberry, and the proposed EGS Project, many of which were picked up by Internet news websites and blogs. At least 6 of these were printed and 1 television news story was aired during the scoping period between October 21, 2010 and November 22, 2010.

1.8 Identification of Issues

BLM received nine comment letters from the public in response to the Scoping Notice and considered these as well as comments made during the public meetings. All comments were considered, and substantive and relevant comments and concerns are addressed in the environmental analysis. The letters and the scoping analysis report are on file and publically available at the Prineville BLM office.

Concerns and topics raised by the public, as well as those raised by specialists from the three cooperating agencies, were reviewed and used to develop “key issues” and help guide the EA. A decision instrument was used to identify these key issues by evaluating the comments and accessing how the issues and concerns can be met by customary and usual methods. For example, some issues are dealt with by following the Deschutes LRMP Standards and Guidelines; other issues are resolved by following best management practices (BMPs); and others are resolved through project design features or mitigations. Any issues or concerns not already met by these methods that are within the scope of the project become key issues. A copy of this decision instrument is on file at the Prineville district office. Key issues describe potential effects on a specific resource that may be relevant to the environmental analysis and will therefore be analyzed and discussed in detail in the EA.

Following review, BLM determined that other concerns submitted were beyond the scope of analysis and would not be considered.

Issues Considered But Not Brought Forward for Detailed Analysis

Disturbance of Forest Vegetation and Timber Stands

The proposed project area lies within extensive areas of past, present, and future vegetation management, thinning, and timber harvesting projects. The EGS Project would disturb a very small amount of land (2/3 acre) in comparison to these and other forest projects. The EGS Project and other geothermal projects have been designed to: minimize the type and amount of vegetation to be removed; require as small amount of surface disturbance as possible; and utilize sites that are adjacent to existing roads, clearings, and areas that have otherwise already been disturbed and are likely to soon be disturbed again. All of the sites requiring ground disturbance were located to use natural openings and avoid the cutting of large trees. As a result, impacts to forest vegetation and timber stands would be negligible.

Effects to Socioeconomics

The Project would have a small but positive effect on socioeconomics in terms of local workers hired during project implementation and each project's use of local facilities, services, and goods purchased from businesses in the La Pine, Sunriver, and Bend communities. As an example, drilling of the production wells would be the most labor-intensive phase of the project. The drilling of each well would be supported by two crews (approximately 12 people in total) with each crew working 12-hour days for an estimated 90 days per well. These effects would certainly be beneficial to certain specific businesses and individuals, and would have a minor beneficial impact to communities close to the project site (such as La Pine and Bend). The number of workers involved though would be small, as well as temporary, and would not be expected to impact community services. As a result, socioeconomics in the Project area would not be substantially changed.

Effects to Infrastructure: Utilities, Energy, and Materials

The Project would occur on National Forest System (NFS) land, which has limited infrastructure that could be affected. Project crews would use existing roads and would provide their own fuel to support vehicle and equipment use. Fuel (gasoline and diesel) used during the Project would be a consumptive use of these products, but it would be temporary, short-term, and a relatively small quantity compared to the regional market. The work force associated with the Project would similarly not be expected to affect utilities available in local communities.

Effects to Transportation

BLM and FS determined transportation was not an issue to be considered for detailed analysis due to the small scale and limited duration of the Project. A small number of vehicles and equipment would be involved, which would routinely utilize the highway system to reach job sites. Once on National Forest land, existing roads would be used

and Forest Service road maintenance standards would apply. Vehicles using the roads would include heavy equipment, service vehicles, road maintenance equipment, fuel trucks, and pickup trucks. Traffic may be frequent at times, such as when a number of vehicles are needed to deliver drill rig equipment. Peak vehicle traffic would occur during the mobilization and setup of the drill rig. Approximately 30 truckloads of equipment would mobilize over a 7-day period. After that, typical traffic would consist of a fuel truck approximately 2 times a week, a daily water truck for dust abatement during dry months, and approximately 10 pickup trucks to transport the drilling crew each day during the planned drilling period of 180 days (two discrete 90 day periods approximately 4 months apart). The access routes proposed use FS roads that are designed to handle large vehicles. The Proponent, in coordination with FS, would post signs notifying the public of industrial traffic and will meet Manual for Uniform Traffic Control Devices standards. Project vehicles would use CB radios to alert others of ingress and egress. Road signs reminding vehicles to use CB radios are already posted on the main access road to the site (FS road 9735). During the Project, some FS roads would be closed to the public. These roads (roads 600, 680, 558, 550, 510) have been closed as part of the Newberry Geothermal Exploration project approved in 2007. Road signs clearly indicate that the road is closed at the locked gate. Because of the limited scale and duration, and implementation of the project and design features mentioned above, the project would be expected to have minimal effects on transportation.

Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations,* directs federal agencies to address environmental and human conditions in minority and low-income communities. The evaluation of impacts to environmental justice is dependent on demonstrating that significant, adverse impacts from the proposed EGS Project are not disproportionately borne by any low-income or minority groups in the affected community. The Project location is on NFS land and the proposed actions would have very limited potential for direct effects on communities that border the NFS land. As such, analyses in the EA do not indicate a potential for more than minimal adverse impact to the human population.

Management of Health, Safety and Hazardous Materials

The Proponent would use best management practices to address the general and proper management of waste to be used on the Project. At certain times hazardous materials may need to be used. These would be transported, handled, utilized, and disposed of properly and according to federal and state requirements for each product. Safety, including the safe and proper handling of waste and hazardous materials, would be an integral part of Project implementation. Material Safety Data Sheets (MSDS) for all hazardous chemicals are on file at the Prineville BLM office.

Effect to Cultural Resources

Surveys for cultural resources are conducted for each project that occurs on the Forest, including the EGS Project. Cultural resource surveys have been conducted on all proposed areas where new surface disturbance would occur. No cultural resources were identified during the intensive pedestrian survey of MSA locations. No historic

structures, historic districts, or traditional cultural properties were identified during the records search.[2]

As with all projects on NFS land, if any cultural resources are uncovered during Project operations, work would immediately stop at the site where artifacts were uncovered, the FS archaeologist would be notified and work would not resume until appropriate treatment recommendations were obtained from a qualified archaeologist. The Cultural Resources Inventory Report is on file at the Prineville BLM office. As a result of the negative findings in the cultural resources surveys and the appropriate mitigation steps should any cultural artifacts be found, there would be no impact to cultural resources.

Disturbance to Threatened, Endangered and Sensitive Plants

A Biological Evaluation (BE) of the Project Area was completed in July of 2011 for Threatened, Endangered and Sensitive Plants. The evaluation concluded that the proposed action would have no impact on Proposed, Endangered, Threatened, or Sensitive plant species. This BE is on file at the Prineville office of the BLM.

Effects to Noise Levels

Noise from equipment, vehicles, and machinery are customary for geothermal and timber projects and would be most evident at close range within each project site. Sound levels from drilling deep geothermal wells are estimated to be up to 45 A-weighted decibels (dBA) at a distance of 0.5 miles.[3] This sound level is consistent with that of a library or a quiet room in a residence. The closest potentially sensitive receptor to the Pad S-29 site where the majority of project activity will occur is the Peter Skene Ogden Trail (TR 56), which is 0.75 miles to the south and the closest noise sensitive property is the Paulina Lake Campground and Lodge located 2.3 miles to the east. Any noise from the drill rig at these two locations would be less than 45 dBA and within Oregon noise control limits. Additionally, during the drilling of well NWG 55-29 in the summer of 2008 there were no reports of noise complaints to the FS. The project would have minimal noise effects due to the short-term nature of the activities and the remote location with respect to noise sensitive locations.

Effects to Air Quality

Emissions from the Project would include fugitive dust emissions from road use and construction equipment and diesel engine exhaust from the stimulation and drilling of the two production wells. Vented steam from the production wells may contain hydrogen sulfide and other non-condensable gases.

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[2] Cultural Resources Inventory and Monitoring Program, Newberry Volcano EGS Demonstration Project-MSA Location Study, Basin and Range Heritage Consultants, LLC, November 2011.

[3] Newberry Geothermal Pilot Project Final EIS, June 1994, p. 4-69.

Given the small size of areas needing earthwork (2/3 acre) and the small fleet of vehicles routinely needed for stimulation and drilling operations (less than 20), fugitive dust emissions would be minimal. The Proponents would use water trucks for dust abatement, as per FS requirements, on the most traveled access roads during dry months. This would further reduce dust generation. Fugitive dust emissions from the project are not expected to have an adverse impact on air quality.

Venting steam from production wells during short-term flow tests and the longer 60-day circulation test may contain hydrogen sulfide (H_2S), a non-condensable gas commonly encountered in geothermal activities. Because the vented steam would be heated groundwater injected from the surface and not naturally occurring geothermal steam traditionally found in conventional hydrothermal geothermal systems, it is anticipated H_2S concentrations would be minimal (1 ppm or less) if detectable at all. Nonetheless, H_2S monitoring and abatement equipment would be on site and used during well testing. Continuous abatement of H_2S emissions would be applied if measured concentrations and flow rates indicate an emission rate greater than 5 lb/hr, an industry standard H_2S emission limit.

Diesel combustion emissions would be emitted from well stimulation and drilling equipment and vehicles used to access the project site. Air quality impacts from a similar, but much larger proposed geothermal pilot project in 1994, were analyzed in detail. The analysis determined that these emissions would not add substantially to the levels that exist in the region from other sources such as highway travel, forestry practices, and recreational activities.[4]

To the extent that some of the present and future actions could occur at the same time as the proposed EGS Project, there would be an addition of small quantities of air emissions from equipment, vehicles, and dust from each of the projects, but cumulative totals would not be expected to have measurable effects on regional air quality.

Effects to Land Use

The proposed project is on National Forest System lands and will conform to existing land management direction.

Effects to Wilderness Areas, Potential Wilderness Areas, Inventoried Roadless Areas, Wild and Scenic Rivers

There are no Congressionally designated wilderness areas in or near the Project area. A portion of Paulina Creek is identified as being eligible as a wild and scenic river but it is not designated as wild and scenic; neither Paulina Creek nor any of its features would be affected by this Project.

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[4] Newberry Geothermal Pilot Project Final EIS, June 1994, p. 4-17.

MSA Site NM40 is within the North Paulina Inventoried Roadless Area (IRA), but the 2001 Roadless Area Conservation Rule does not apply to activities that don't include road building or tree cutting. The IRA meets the criteria for Potential Wilderness, but the activity proposed at MSA NM40 (surface installation of monitoring equipment) will not affect or change the wilderness character of the area.

Impact on Winter Recreation

Preparation and drilling of the downhole MSA sites could occur during the winter months and some of the access roads are on FS roads that are used by snowmobiles during the winter. A detailed discussion of proposed access routes in relation to snowmobile trails, and project design features incorporated to reduce impacts is discussed in Section 2.6. These project design features would allow simultaneous use of the roads by both snowmobiles and Project equipment, therefore impacts from the Project on winter recreation is anticipated to be minimal.

Irreversible and Irretrievable Commitment of Resources

The irreversible commitment of resources is described as the "loss of future options." It applies primarily to non-renewable resources, such as cultural resources, or resources that are renewable after a regeneration period, such as soil productivity. The term may also apply to the loss of an experience as an indirect effect of a "permanent" change in the nature or character of the land. An irretrievable commitment of resources is defined as the loss of production, harvest, or use of natural resources. The amount of production foregone is irretrievable, but the action is not irreversible. No irreversible and irretrievable commitment of resources is expected.

Intentional Destructive Acts

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

KEY ISSUES TO BE CARRIED FORWARD, ADDRESSED, AND ANALYZED IN DETAIL

Key issues are those that represent a concern that requires more detailed analysis and a consideration of the trade-offs involved in choosing one alternative over another.

Chapters 3 and 4 of this EA provide the description and analysis of the key issues identified by BLM, FS and DOE.

WILDLIFE KEY ISSUE

Preparing and clearing the vegetation for the three borehole MSA stations have the potential to remove habitat on these sites for some species. Drilling activities, testing and stimulation activities, and an increase in human disturbance also have the potential to disturb nesting sites up to ¼ mile during the breeding season or temporarily displace some wildlife species.

The Deschutes LRMP Wildlife Standards and Guidelines that support these issue statements include: WL-1 --5, 11, 12, 19, 20, 28, 29, 31, 33, 34, 56, 72, and 73.

- UNITS OF MEASURE:
  - Distance between drill sites and nesting sites.
  - Area of habitat removed.

SCENIC RESOURCES KEY ISSUE

Removal of vegetation on the microseismic monitoring sites has the potential to cause up to 3 areas of approximately 9,375 square feet (0.2 acre) each or a total of 28,125 feet (2/3 acres) to not meet the Forest Plan standards for visual quality as seen from selected viewpoints. The Deschutes LRMP Standards and Guidelines that supports this issue statement is M8-19. The venting of steam during the short and long term circulation tests may also create a steam plume that could potentially be visible at times from certain selected viewpoints. The drill rig and circulation testing facilities may be visible at times from some key viewer locations during the anticipated 2-year duration of the Project.

- UNITS OF MEASURE:
  - Number of sites and size in acres of areas that would have vegetation removed sufficient to be seen from key viewer locations.
  - The distance from selected viewpoints and ability to be seen by Forest visitors.

GROUNDWATER QUANTITY KEY ISSUE

Withdrawal of groundwater from water wells for the development and testing of a belowground EGS reservoir has the potential to reduce the quantity of water available for other uses within the Deschutes drainage basin.

- UNITS OF MEASURE:
  - Total amount of groundwater to be withdrawn in millions of gallons and rate of groundwater to be withdrawn in millions of gallons per day.

Groundwater Quality Key Issue

The development and testing of a belowground EGS reservoir has the potential to negatively impact groundwater quality within the aquifer.

- Units of Measure:
  - Amount, type of additives and depth at which they are to be injected. Injection and production well design features to prevent contamination of the groundwater aquifer.

Induced Seismicity Key Issue

The development of a below-ground EGS reservoir by hydroshearing has the potential to produce induced seismicity and increased seismic risk that could affect historic structures, resorts, and other recreation sites within the NNVM, could increase avalanche risk, could increase risk to above and below ground geologic features, and could result in property damage in nearby population centers.

- Units of Measure:
  - Probability of exceeding peak ground acceleration (PGA) above 0.028 g[5], due to EGS activities, calculated at well pad 55-29, Paulina and East Lake Resorts and campgrounds, Lava Lands Visitor Center, avalanche-prone sites on North Paulina Peak and Paulina Peak, and the nearest population centers of La Pine, Sunriver, and Bend.

1.9 Decisions To Be Made

BLM–Lead Agency

The District Manager of the Prineville District BLM will make the decision whether to approve, approve with conditions, or deny the Proponents' proposed Plan of Exploration, Operations Plan, and Drilling Program.

This EA provides analysis used by BLM to determine whether it can issue a Finding of No Significant Impact (FONSI) or whether it is necessary to prepare an Environmental Impact Statement (EIS). "Significance" is defined by NEPA and in regulation 40 CFR 1508.27. If the District Manager determines that this Project does not present a substantial question as to whether it may have significant effects based on the environmental analysis documented in this EA, a Decision Record (DR) will be issued approving a selected alternative, whether it is the Proposed Action or another alternative. A DR and FONSI statement document the reasons for the selected

[5] 1 g is the acceleration due to gravity. A PGA of 0.028 g is perceived as "light shaking" by USGS standards.

alternative, why it would not result in significant environmental impacts, and how it meets the Purpose and Need from Section 1.4 of an EA.

Forest Service and DOE–Cooperating Agencies

The Forest Service is involved in the environmental analysis under the terms of a cooperative agreement between BLM and Forest Service. The Forest Service will make a separate NEPA decision and issue a FONSI, or declare the need to prepare an EIS, on those 9 MSA stations that are not on geothermal leases administered by BLM,

As a cooperating federal agency, DOE will make the decision whether or not to authorize the expenditure of federal funds for the proposed EGS project. DOE will make a separate NEPA decision and either issue a FONSI or declare the need to prepare an EIS.

CHAPTER 2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

2.1 INTRODUCTION

This chapter describes three alternatives analyzed for the purpose of this EA: Alternative A, the Proposed Action; Alternative B, developed to address concerns raised during the scoping process over water usage and visual impact; and Alternative C, the No Action Alternative. A brief discussion of alternatives considered, but eliminated from further analysis, is also included.

2.2 PROJECT LOCATION

The proposed project area is located approximately 22 miles south of Bend and 10 miles northeast of La Pine on National Forest system lands within the Bend-Fort Rock Ranger District of the Deschutes National Forest (Figure 1: Project Vicinity Map), in Deschutes County, Oregon.

The primary project activities would occur on an existing well pad, S-29, completed by Davenport in 2008. S-29 is approximately 5 acres in size, and is located on federal geothermal lease OR40497 held by Davenport Newberry LLC in Section 29, Township 21 South, Range 12 East. Nearby there would be 20 microseismic monitoring stations. All of the MSA stations would be located on National Forest system lands. Eleven (11) of the sites would be on federal geothermal leases, where NEPA decisions for surface disturbance is under the jurisdiction of the BLM, and nine 9 stations would be on lands where FS will make the NEPA decision for surface disturbance (Table 1).

2.3 ALTERNATIVE A—PROPOSED ACTION

This alternative is based on the Notice of Intent to conduct geothermal resource exploration operations submitted by the proponents and the associated Plan of Exploration, Operations Plan and Drilling Program. The description of this proposed action will include a brief overview of the objectives, intent, and a simplified summary description of the processes involved. This will be followed by a detailed description of the key parts of the project:
Phase II[6]

- Drilling three new MSA boreholes
- Installation and calibration of the final microseismic array
- Stimulation and testing of the injection well
- Drilling, stimulation, and testing of two production wells
- Long-term circulation test

[6] Phase I, was permitting, public outreach and collection of baseline seismic data.

Project Overview

The proposed project would create and test an EGS reservoir beneath an existing geothermal well pad (S-29) that Davenport constructed in 2008. Creation of the belowground EGS reservoir would be accomplished by using a process of well stimulation termed 'hydroshearing'. Hydroshearing is the process of opening minute cracks in the subsurface rock formations along existing natural fractures. In the proposed Project this would be accomplished by injecting groundwater deep (at depths of approximately 6,500 to 10,000 ft) into the existing geothermal well, NWG 55-29, located on pad S-29. Shallow groundwater wells (approximately 600 to 800 ft deep) located at and near the site would be used to provide water for the project. The desired outcome of this phase of the project is to establish an underground network of interconnected fractures in the hot rock that would serve as a heat exchanger. When cold water is pumped from the surface it becomes heated as it flows through these subsurface fracture systems. Once this is accomplished, heated water within the reservoir would be returned to the surface by directionally drilling two additional deep geothermal wells on the same well pad that would intercept the EGS reservoir and allow the naturally heated water to be circulated between the wells.

Minute fractures created during the hydroshearing process would be mapped and carefully controlled and monitored. Monitoring and mapping would be accomplished with an array of microseismic monitoring equipment (microseismometers) installed either just below ground (surface stations), or in boreholes (borehole stations) drilled to a depth of up to 1,100 feet. Ten (10) locations would be surface stations and 10 would be borehole stations (Figure 2). The microseismic array ("MSA") stations would be strategically and carefully distributed to provide the highest degree of seismic sensitivity and accuracy. This MSA would monitor the hydroshearing process in real time.

Of the 10 MSA borehole locations, 3 new boreholes would be drilled using a truck-mounted rotary drilling rig similar to those used to drill domestic water wells. Existing well sites, or sites already approved for such wells, would be utilized for 7 of the 10 proposed borehole MSA stations needed to support the required monitoring for the project. Each site for the MSA boreholes would average approximately 75 ft x 125 ft (9,375 square feet or 0.2 acre) to safely accommodate equipment, including a drill rig and water truck. Total surface disturbance for all 3 new borehole stations would be approximately 28,125 square feet (2/3 acres). All sites are accessible from existing Forest Service roads and no new roads would be constructed.

Once the underground EGS reservoir is successfully created, and two additional deep geothermal wells are drilled and tested, a long term circulation test of approximately 30-60 days would be conducted to test reservoir performance. This data would be used to create a conceptual model of how a hypothetical EGS wellfield and power plant might function. The test system would not use geothermal energy to produce electricity and a power plant is not proposed at this time.

Installation of Microseismic Array (MSA)

Final installation of the microseismic array would require:

- Preparing the new borehole and surface MSA sites for the monitoring equipment
- Placing downhole seismometers
- Calibrating the borehole and surface MSA sites
- Installing a centralized data relay station

The potential MSA borehole sites are shown in Figure 2. The steps involved in drilling and completing these MSA boreholes are described below:

For the three new boreholes:

1. Prepare sites for drill rig access. The three new sites are accessible from existing FS roads; no new roads would be necessary. Road clearing, grading, and brushing may be necessary on the roads shown in
2. Figure 3. The sites are all relatively flat. Only minor grading (no cut and fill necessary), if any, would be required at each site to accommodate the rig and associated equipment. The three new proposed borehole sites are located on sites that have previous disturbance. Vegetation that will need to be cleared is made up of immature lodgepole pine with some ponderosa, approximately 6-20 feet in height. Trees needing to be cut at the new borehole MSA sites would be left on the ground or piled within the immediate area to provide down woody debris. This would provide habitat for prey species for raptors, woodpeckers, or martens. Live green trees or snags greater than 15 inches dbh (diameter at breast height) would not be cut without prior FS approval.
3. Drill 6-1/4-inch outside diameter boreholes to approximately 1,100 feet using a truck-mounted rotary rig. Surface casing would be necessary to prevent near-surface collapse or filing in of the newly created wellbore in poorly consolidated surface materials. The holes would be cased with 4-inch diameter PVC or steel closed-end casing and cemented from the bottom to the surface. Water for drilling would be trucked in from existing groundwater wells on pads S-16 and S-29 or from off site water sources in La Pine. The water would be delivered to the drilling sites by up to two 3,500-4,500 gallon water trucks. Water usage would be 2,000-3,000 gallons per day for the approximately 14 days of drilling time anticipated per well. Average water delivery is expected to be less than one water truck per day for each well. No sumps would be constructed on the pad site. All mud and cuttings would be contained in free standing tanks and disposed of at approved receiving sites in accordance with BLM requirements.

For all of the selected borehole sites:

4. Install microseismic monitoring equipment downhole and place a weatherproof housing (approximately 3 feet by 3 feet) on the surface at each site. Install adjacent solar panel and telemetry antenna. Solar panels and telemetry antennas at some sites could be as much as 300 feet from the seismic station. It is anticipated that in most cases, the telemetry equipment would be attached to a nearby tall tree.

However, in the event it is not feasible to attach the antenna to a tree, a 10-40 foot telescoping pole would be used to hold the antenna. The pole would be connected to the borehole surface equipment by hard wire. Depending on the height of the pole, a hole would be dug with a shovel to about 2 feet deep, then a posthole digger would be used to go another approximately 2 feet (for the taller poles) and the pole would be cemented into place. In addition to the hard wire to connect the pole to the borehole equipment, taller poles require wires that are secured into the ground. Installation would take 11 weeks for all stations, followed by calibration and testing for approximately 2 weeks. Figure 4 shows a typical MSA station.

Figure 4: Typical MSA Station with Solar Panel And Telemetry Antenna

FOR SURFACE MSA STATIONS:

The 10 Surface MSA stations would be identical to the borehole MSA stations except that the seismometer would be placed in a shallow hole 1 to 4 feet deep and less than 2 feet in diameter. These holes would be hand dug.

5. To determine the optimum seismometer array deployment, the response of each potential station location to seismic energy released in the reservoir must be calibrated. Calibration can be accomplished by producing a seismic signal at each of

the stations and deploying a seismometer deep in the target well (NWG 55-29) or a suitable alternative location, to monitor response ('surface calibration').

Surface Calibration - In the surface calibration method, seismic energy is produced using explosive charges deployed into shallow calibration holes (shot holes), 15-30 feet in depth. These calibration shot holes would be located on the same sites as the MSA locations and would not require additional surface disturbance. The procedure is as follows:

- Drill shot holes (3-4 inches wide, 15-30 feet deep) with a small truck mounted rotary drill.
- Line shot holes with PVC casing and install cap flush with the ground surface.
- Load shot hole with Pentolite explosive.
- Backfill and tamp native soil into the PVC casing and shot hole.
- Cover shot hole with rubber mat, 3 ft x 3ft x 1-inch thick high-density aluminum plate, and sand bags.
- Fire shot and record signal on the seismographs.
- Once the calibration is successfully completed the shot holes would be filled with dirt and the shot hole location restored to the satisfaction of the FS.

6. Upon completion of activities related to the project (anticipated during the summer of 2014), the boreholes would be plugged and abandoned according to BLM specifications. The MSA equipment, including all associated wires, telemetry poles and cement footings, solar panels and batteries would be removed, and the sites would be restored to a vegetated condition capable of growing forest landscapes similar to those in place prior to disturbance in accordance with Forest Service and BLM specifications. This will include re-contouring any graded pads to match surrounding topography, spreading stockpiled top soil/overburden, and replanting vegetation.

   Surface MSA stations would be identical to the borehole MSA stations except that the seismometer would be placed in a shallow hole 1 to 4 feet deep and less than 2 feet in diameter. These holes would be hand dug.

Install repeater station(s):

In order to relay the data to a central location, up to two telemetry repeater stations would be installed. These stations would consist of an antenna, solar panel and battery. The antennas would be placed high up in a tree near the repeater station and would be visually inconspicuous. One telemetry repeater may be located in Section 16, just north of S-16, and the second one may be located in Section 21, just south of S-16.

Stimulate and Test Injection Well

Development of the EGS system involves the creation of an artificial reservoir in suitable hot rocks where water can circulate through and heat up, much like the heat exchange process of a radiator. During this process, water would be injected at high pressure

(estimated to range between 1,160 and 2,600 psig) into well NWG 55-29, to depths of approximately 6,500 to 10,000 feet below ground.

To create a network of optimum fracture width, fracture density and overall dimension, hydroshearing stimulation would be conducted at multiple levels or fracture sets in the target well. The advantages of stimulating at multiple levels include:

- Creating a larger reservoir volume, thereby doubling or tripling available heat exchange area.
- Enhancing system permeability and connectivity to allow for higher production rates and lower injection pressures, thereby increasing the economic viability of any future project.
- Establishing a single-well production total mass production rate of 75 Kg/s.

A formation injection test would be conducted to determine the upper constraints for a hydroshearing treatment design by defining the magnitude of the minimum horizontal principal stress. This will identify the tensile failure pressure of a specific formation resulting from high pressure, low volume injection, so that formation breakdown pressure is not exceeded during the main stimulation treatments. This stress magnitude is a critical component of volcanic stress regime and can only be identified through formation injection test analysis.

The objective of stimulation is to create up to three separate and stacked fracture sets. Stimulation would be accomplished by pumping groundwater into the injection well at relatively high pressure (but at a pressure low enough to prevent tensile failure and formation breakdown) to hydroshear the shallowest pre-existing wellbore fractures below the casing shoe. Diverter materials, discussed below, are used to direct the stimulation fluid to specific areas of pre-existing fractures, previously identified by a borehole televiewer survey.

Use and Application of Diverters

The creation of EGS reservoirs has historically involved the stimulation of a single fracture set around an existing well bore. This is because during stimulation the existing fracture with the lowest hydroshearing pressure will open when water is pumped from the surface and pressure is applied in the injection well. The other existing fractures, that require a higher shear pressure, are typically not affected (Figure 5).

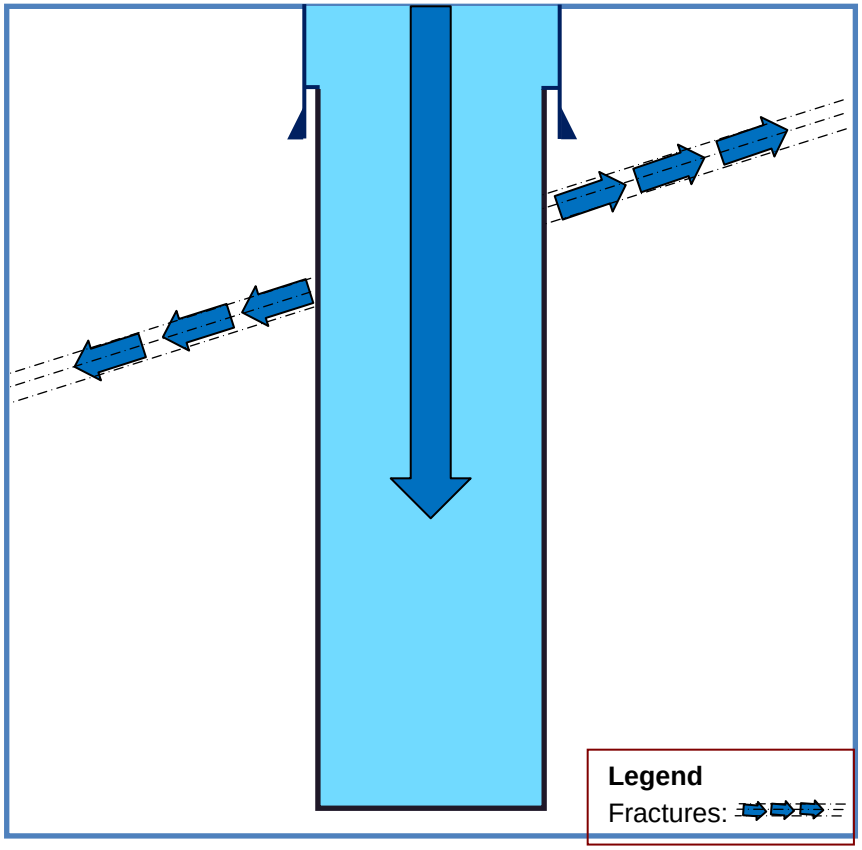

Figure 5: Stimulation of a Single Fracture Set

The stimulation of multiple fracture sets in a single injection well will increase EGS efficiency. Creation of multiple fracture sets in a single well requires hydraulic isolation of each fracture network after it has been stimulated. To provide hydraulic isolation for the creation of multiple fractures, a diverter material can be used (Figure 6). After the stimulation of the first fracture set, a diverter material is applied to temporarily seal the fracture network from accepting additional fluid. Additional pressure is then applied to the well and a second set of fractures is stimulated. After multiple fractures are created injection is discontinued and the well bore is allowed to reheat to the original well temperature. This causes the diverter material to dissolve, leaving all fractures open for circulation and flow during the operation of the EGS system (Figure 7).

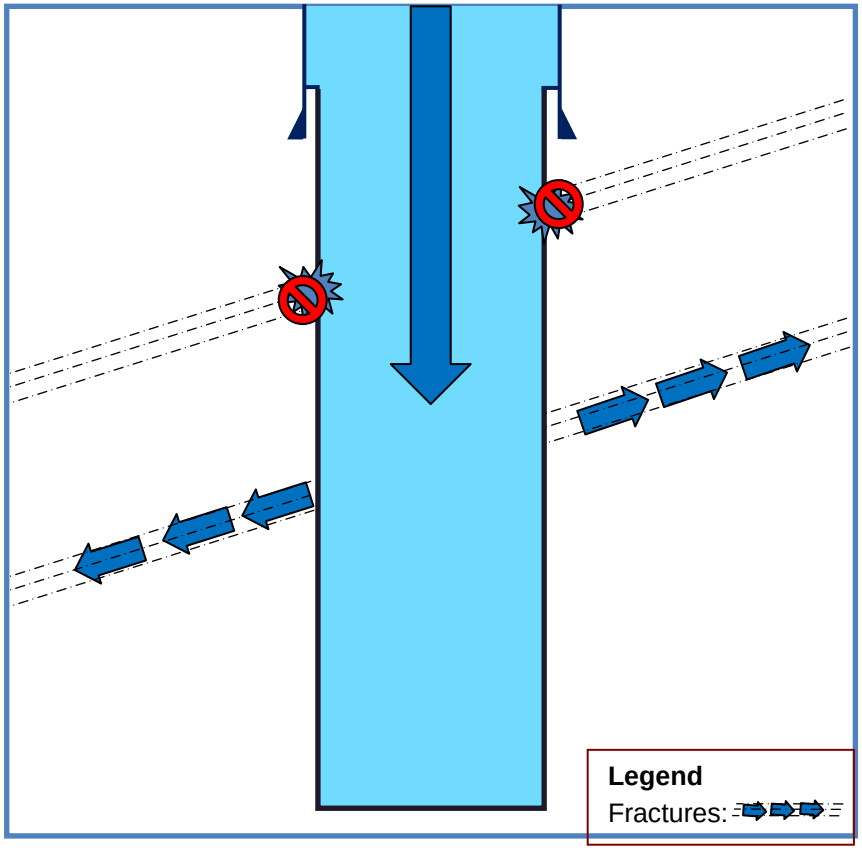

Figure 6: Stimulation of Second Fracture Set After Diverter Application to First Fracture Set

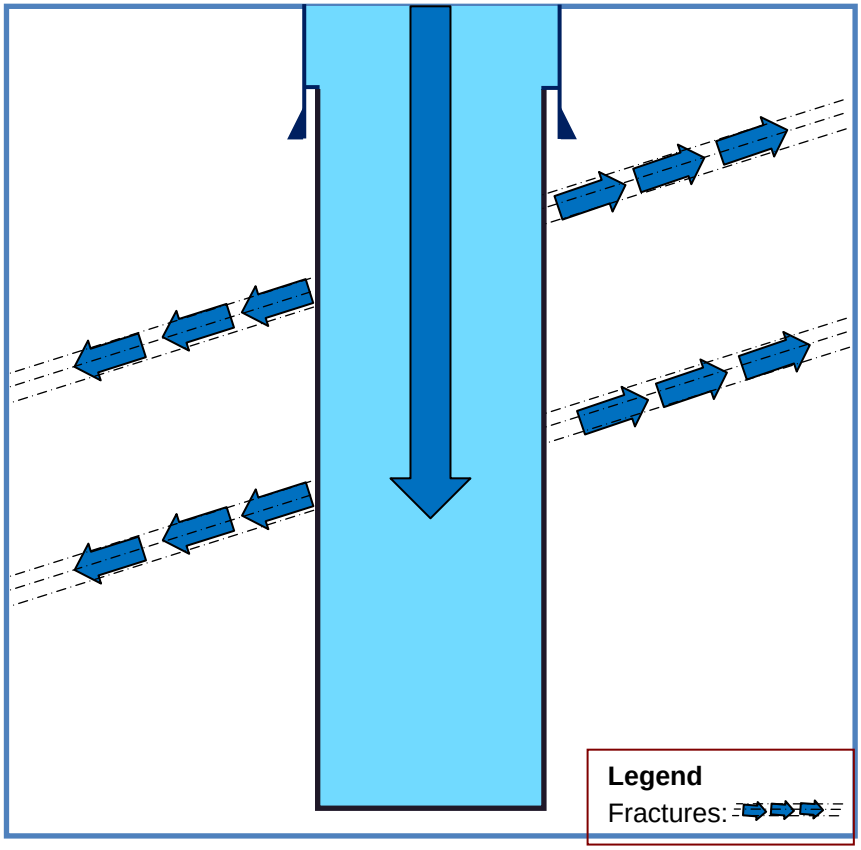

Figure 7: EGS Well with Multiple Fracture Sets after Diverter Dissolution

Proprietary diverters[7], primarily developed by AltaRock, would be used between pumping of the stimulation treatments for each fracture set. Diverter materials are selected to be environmentally benign and to have benign breakdown products. The diverters would be selected from two classes of materials: biodegradable plastics and naturally occurring minerals.

Biodegradable plastics are plastics that will decompose in natural aerobic (composting) and anaerobic (landfill) environments. They may be composed of either bioplastics, which are plastics with components derived from renewable raw materials, or petroleum-based plastics, which utilize an additive. The use of bio-active compounds, compounded with swelling agents, ensures that, when combined with heat and moisture, they expand the molecular structure of the plastic and allow the bio-active compounds to break the polymer chains into their component, soluble parts. These smaller components can then be metabolized if they are in the biosphere.

[7] AltaRock has a portfolio of patent filings protecting its proprietary technology and methods.

For example, one of the diverter materials made from renewable biologic raw materials that AltaRock has used is BioVert™, a polymer of lactic acid, or PLA. This material is a hard plastic that is available as grains that can be sorted by size. When heated, the chains in the polymer break down to lactic acid, a soluble substance found in human and animal tissue as a normal product of metabolism and exercise. Three of the other biodegradable plastics that could be used are also made from biologic materials. Two others are derived from petroleum, but break down into small components that are bioactive and can be metabolized in the environment. Biodegradable plastics would be selected based on the temperature at which they melt and then the temperature at which they dissociate.

Well NWG 55-29 is very hot (> 600 º F), but would be cooled by injecting water for the stimulation. The diverter material selected needs to stay in place long enough to stimulate the remaining zones. The first zone stimulated may not be cooled enough to make it possible to use a biodegradable plastic as a diverter. If this were the case, one of the mineral diverters would be selected for that zone.

The mineral diverters that may be used are all naturally occurring materials that would be ground to a specific particle size and mixed with clean groundwater to pump into the well. A variety of diverters have been selected for varying solubility over a wide range of temperature. One possible mineral that has been tested is calcium carbonate (calcite). Because any natural mineral material can have contaminants that are toxic, AltaRock uses materials that have been quality controlled and tested to have very low contaminants. For example, the calcite selected for use as a diverter is very pure, with greater than 99% calcium carbonate and less than 0.3% quartz.

Water would be pumped for about seven (7) days to stimulate each fracture set. Stimulation of at least three fracture sets is planned, for a total of twenty-one (21) days of pump time. When the desired water volume for each fracture set has been pumped and the target fracture volume has been stimulated, a suspension of diverter particles would be pumped into the well. The amount of diverter material is expected to be between 100-250 pounds per diverter treatment. The particles would be carried down to the fractures that are currently accepting water. The particles would pack off in the fractures at the well bore face and seal off additional flow into the fractures (Figure 6). Additional pump pressure would be applied and a new set of fractures, typically below the first set of fractures, would be stimulated. Pumping would continue until the second fracture set grows to the target volume. This process would be repeated again to stimulate a third fracture set. It is expected that at least two applications of diverter may be required for each stimulation.

Handling and Storage of Diverter Materials

Diverter materials are stable, non-toxic, granular solids of various particle sizes. Materials would be stored on the S-29 pad location in 50-100 lb sacks, 55-gal drums or super sacks (35 ft^3 polyethylene sacks). Material would be protected from the weather with plastic wrap, covering, and stored in a protected area such as under a canopy or in a trailer. A total of 1000-2000 pounds of each selected diverter would be on hand at the well location during the stimulation phase (approximately 3 months). A Material Safety

Data Sheet (MSDS) will be included with diverter material during shipment to and from storage at the site for inspection by appropriate regulatory agencies.

Composition of Potential Diverters and Their Degradation Products

Below is a list of potential proprietary diverter materials that might be used in the Project. One or more of these proprietary products may be used during the stimulation based on the results of ongoing proprietary site investigations and laboratory testing of diverter performance. The Proponents anticipate pumping three stimulation stages by using approximately 100-250 pounds of diverter between stimulations, with one diverter treatment pumped between the first and second stimulation, and another treatment pumped between second and third stimulation.

Table 2: Diverter Material and Expected Degradation Products (Altarock Proprietary)

Material	Class of Material	Composition of Degradation Byproducts
BioVert™	Biodegradable polymer	Lactic Acid monomers, dimers and trimers
AltaVert ™ 150	Biodegradable plastic from petroleum	Carbon dioxide and a diol. This formulation of the material does not contain bisphenol.
AltaVert 200	Magnesium mineral	Mg^{2+}, Cl^{-}, MgO
AltaVert 201	Magnesium mineral	Mg2+, $(SO_4)^{2-}$, MgO
AltaVert 250	Calcium Mineral	Ca^{2+}, $CO3^{2-}$, $HCO3^{-}$
AltaVert 300	Oxide glass	H_4SiO_4, H_3SiO^{4-}, OH^{-}, H^{+}, Na^{+}, Ca^{2+} Na_2O, CaO, Al_2O_3 , silica polymerization Tobermorite, $Ca_5Si_6O_{16}(OH)_2 \cdot 4H_2O$, reported as a solid residue
AltaVert 301	Natural mineral	H_4SiO_4, H_3SiO^{4-}, OH^{-}, H^{+}, silica polymerization
AltaVert 151	Biodegradable bioplastic	Hydrolysis produces the corresponding hydroxyacids that are mostly non-toxic
AltaVert 152	Biodegradable cellulosic fiber	oligosaccharides and hexoses (mainly glucose)
AltaVert 153	Biodegradable bioplastic	glycolic acid

Two existing groundwater wells, described in more detail in the next subsection below, would provide the water needed for stimulation.

Water would be injected using triplex pumps to shear the shallowest set of pre-existing fractures. The water would be tagged with thermally reactive and conservative chemical

tracers[8] to aid in determination of reservoir surface area, average temperature and fluid travel time. These tracer compounds, used widely throughout the geothermal industry and elsewhere, are not radioactive and are used in very low concentrations.

During stimulation, the Proponents would continuously monitor microseismicity along with surface injection rates and pressures. A fiber optic monitoring system would be deployed in the wellbore to provide real-time distributed temperature information and bottomhole pressure. The orientation and shape of the fractured reservoir created by stimulation, controlled by the *in situ* stress regime at any given depth, would be determined by interpretation of MSA data.

After the well has thermally recovered from stimulation, a three-day, single-well flow test would be conducted to characterize the newly created reservoir. All resulting data (e.g., microseismic, hydraulic, fiber optic and flow test data) would be thoroughly analyzed. The thermo-, hydro-, mechanical-, chemical-model of the reservoir would then be updated.

The typical EGS reservoir geometry observed by microseismic mapping of stimulation treatments at other projects sites is an oblate spheroid, or flattened oval, elongated in one direction. Because previous studies have shown that the fracture system will grow in relatively equal proportions in opposite directions from the wellbore, a three-well configuration (one injector, two producers) proposed by this project is ideal to take advantage of the entire fracture network created by stimulation.

When fracture geometry with a long axis radius of about 500 meters is achieved, a high-temperature diverter material would be pumped in an attempt to redirect the hydraulic treatment to the next set of natural fractures. The resulting temperature, microseismicity and pressure data would be analyzed to determine if the diversion has been successful.

After stimulation is completed, the well would be shut-in (temporarily closed off so that no fluid flows out) to allow for reheating. Thermal expansion of the injected water can result in continued fracture stimulation after pumping is discontinued. If continued fracture growth is indicated by microseismicity, reservoir pressure would be reduced by flowing the well to the atmospheric separator and well pad sump until seismicity subsides and fracture growth ceases.

After sufficient thermal recovery, a single-well flow test would be conducted to allow productivity measurement, wellbore surveys, and tracer and geochemical sampling. Flow test equipment would be installed on the well pad before hydroshearing is initiated. The flow test configuration would include a flow tee, flow control valve, flow

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[8] Conservative tracers refer to tracers that do not react with reservoir fluids or solids, such that the composition and total mass of tracer in the system are conserved.

line with temperature and pressure monitoring instruments, a James tube with lip pressure monitoring, atmospheric separator, and weir box routed to the well pad sump. Ancillary equipment would include a geochemical sampling separator and hydrogen sulfide (H_2S) monitoring and abatement equipment.

Continuous abatement of H_2S emissions would be applied if measured concentrations and flow rates indicate an emission rate greater than 5 lb/hr, an industry standard H_2S emission limit. A James tube and weir box assembly would be used to measure total mass flow and enthalpy (the total energy rate of the system). Liquid and non-condensable gas samples would be collected for geochemical analysis. A suite of production well surveys would be conducted to identify flow zones, calculate the flow contribution of each fracture zone, and to measure heat flow as the well warms up after injection. After a three-day flow test, the well would be shut-in (the master valve would be closed at the well head) while the microseismic, hydraulic, fiber optic and flow test data is analyzed. A second borehole televiewer survey of the injection well may be conducted after stimulation and initial testing to visualize the fracture network wellbore interface.

Water for Stimulation

Two existing groundwater wells would provide the water needed for stimulation. Davenport has an existing water well on well pad S-29 and another water well on pad S-16 and both wells have the necessary water use license required by the Oregon Water Resources Department (OWRD) for use of this water for the Project. Water from the well on pad S-16 would be transported to well pad S-29 via temporary surface irrigation pipelines running alongside FS roads (Figure 8). Where the pipeline crosses a road, it would be trenched into the road and covered with an earthen mound. Water from these wells may be pumped simultaneously to continuously supply stimulation pumps. Groundwater would be pumped into at least eighteen water storage tanks installed on Pad S-29. Each tank holds 22,000 gallons of water, thus the tanks would provide a 396,000 gallon volume buffer and allow the double-lined sumps on both pads to remain empty. From these tanks, multiple diesel-powered pumps would inject the water into well NWG 55-29. The estimated amount of water to be used, along with the timing of that use, is discussed in detail in Chapter 4 – Environmental Effects.

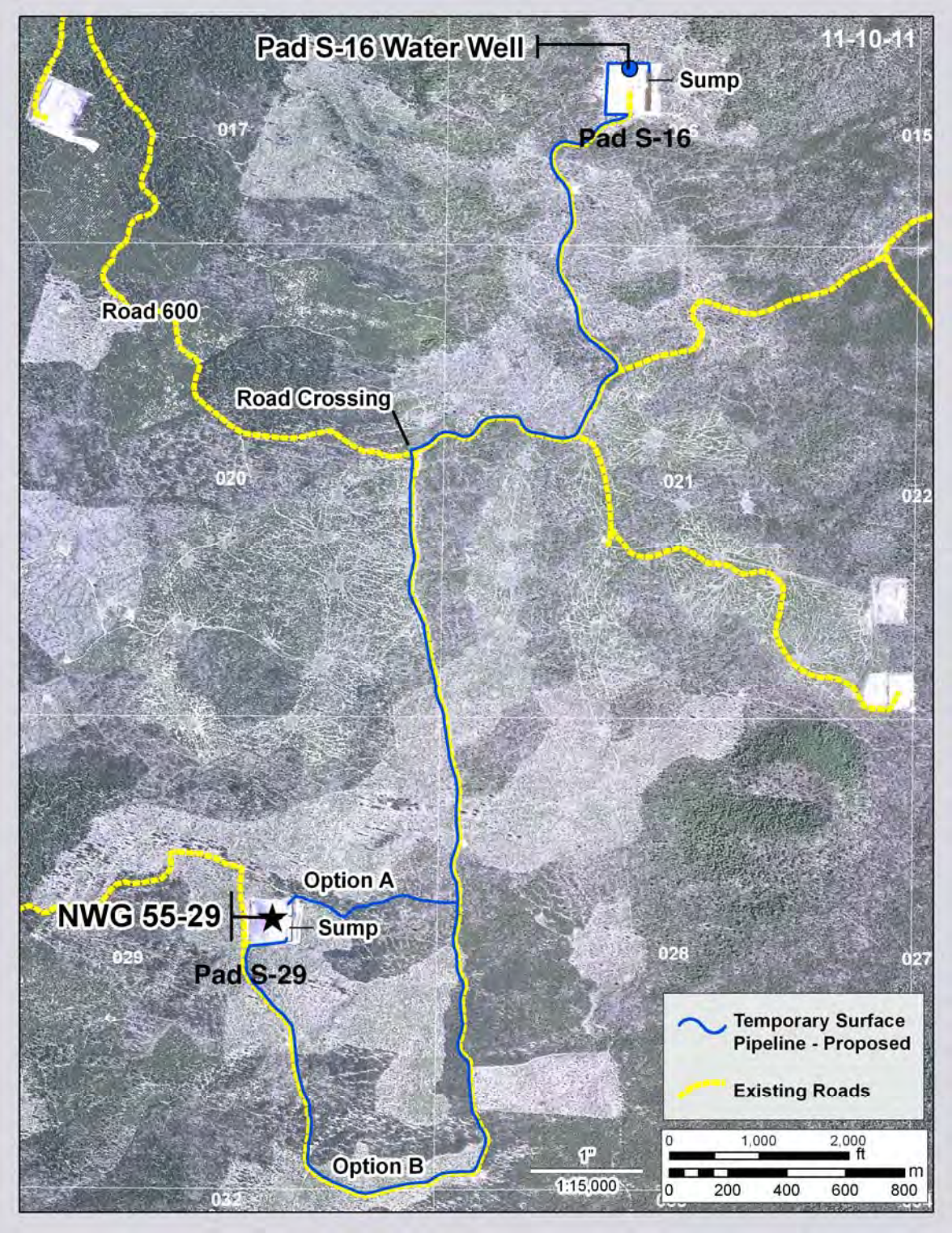

Figure 8: Temporary Irrigation Piping Route

Drill, Stimulate and Test First Production Well

The DOE technical team will review and evaluate a report documenting the results of hydroshearing stimulation and testing, and the feasibility and plan for drilling the first production well. Upon successful completion of this review, the first production well would be directionally drilled from the existing S-29 well pad to intersect the EGS fracture network. Drilling is anticipated to take approximately 75-90 days (24 hours/day, 7 days/week).

After well drilling reaches the planned depth, a series of wireline surveys would be conducted (various instruments are lowered by a steel wire down the well bore) including a sonic, gamma ray, density tool, and acoustic borehole televiewer. The fracture network connection would be evaluated by conducting an injection and production well connectivity test of up to 7 days to allow relatively stabilized flow. Fluid handling equipment required for connectivity testing is similar to that required for testing of the stimulated injection well, with the addition of pumping equipment required to recirculate water from the sump to the injection well.

The reservoir and test system would be filled with groundwater and make-up[9] water supplied by groundwater wells. Connectivity testing would include the use of tracer compounds and frequent analysis of fluid chemistry. The fiber optic monitoring system would be deployed in the production well to observe bottomhole temperature, pressure and flow zone contributions. If the system is found to have too much skin damage[10] or too little transmissivity, a stimulation treatment of the production well would be designed and executed, similar to that discussed above for the injection well. Flow test data would be evaluated and the numerical reservoir model would then be updated.

Drill, Stimulate and Test Second Production Well

DOE would review results from the flow test and make a go/no-go decision on whether to proceed with a second well or not. If DOE and the Proponents decide to move forward with a second production well, the well would also be directionally drilled from the S-29 well pad into the opposite side of the EGS fracture network. Drilling is anticipated to take approximately 75-90 days (24 hours/day, 7 days/week). Drilling, logging and possible stimulation of the second production well would be similar to the procedure used for the first production well, described above. A flow test of up to 7 days would be conducted, identical to that described above for the first production well.

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[9] Make-up water refers to water needed to compensate for losses such as evaporation.

[10] Skin damage refers to the blockage of rock immediately surrounding the well bore, with dried solids for example, leading to low transmissivity and impeded fluid flow in the reservoir.

LONG-TERM CIRCULATION TEST

In this final phase, a 30-60 day circulation test of the injection well and both production wells would be conducted. The long-term circulation test would collect data on fluid temperature, pressure, flow rate, fluid chemistry, fluid pathways and well connectivity to demonstrate the capability of the EGS reservoir to sustain heat extraction, and allow forward modeling of performance over the theoretical life of a power generation facility. As was the case prior to drilling the production wells, the DOE would review and evaluate results to date and the feasibility of plans and budgets prior to moving forward with the long-term circulation test. This test would attempt to establish steady-state operation of the circulating system with respect to injection and production flow, temperature, pressure, enthalpy, makeup water consumption, and gas and liquid geochemistry. During the circulation test, steam would be vented to the atmosphere. This would result in a steam plume that would sometimes be visible during the 30-60 day circulation test. The size, opacity and occurrence of the steam plume would depend on meteorological conditions including temperature, relative humidity, wind speed and atmospheric turbulence (stability class). The FEIS for the Newberry Geothermal Pilot Project (1994) estimated that the steam plume for a 33-megawatt geothermal power plant proposed in the project area could range from 40 feet to 930 feet in height[11]. The entire test facility would be contained on pad S-29 (Figure 9); no new surface disturbance is anticipated. The test system will not use geothermal energy to produce electricity. Portable diesel generators would provide electrical power. Water would be supplied from the groundwater wells described above.

[11] Final Environmental Impact Statement (FEIS) Newberry Geothermal Pilot Project (1994) p. 4-41. Note this was a much larger facility than being proposed here and therefore the steam plume for this project would be smaller.

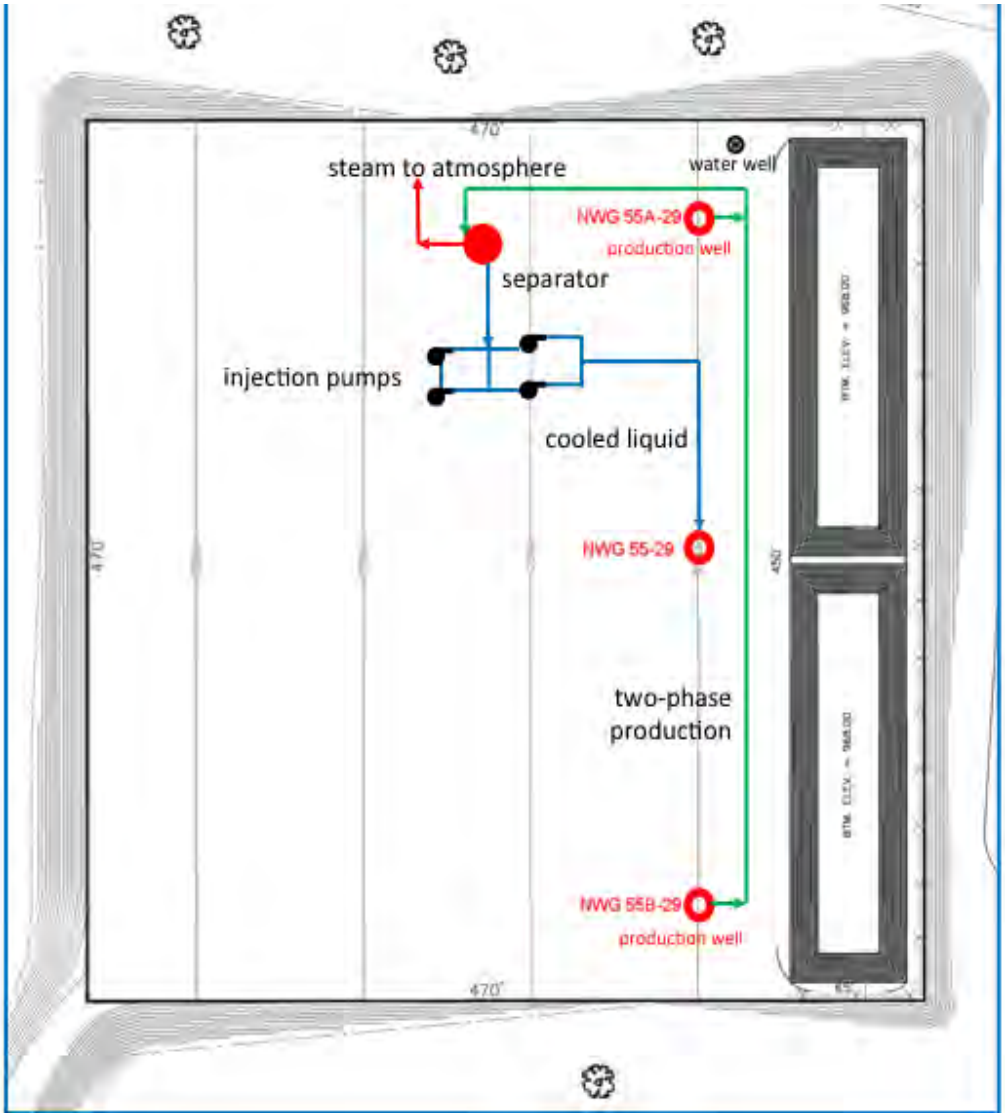

Figure 9: Alt. A – Pad S-29 Circulations Test Facility Conceptual Configuration

The circulation test facility would utilize conventional geothermal fluid processing methods. The test system would be fully instrumented to allow continuous, real-time, local and remote monitoring of temperature, pressure, flow, mechanical systems status and other parameters necessary for comprehensive data collection and operational safety. At a minimum, fluid chemistry would be analyzed daily. The system would be designed for semi-automatic operation, but would be staffed continuously by at least two process control operators.

The two production wells are expected to produce a total of up to 150 Kg/s (1,191,000 lb/hr) of total mass flow, depending on reservoir performance. Production flow would be sustained either by flashing or submersible pump, to a flash separator. The best method for sustaining production flow is highly dependent on the enthalpy of the total flow, which is dependent on several variables related to reservoir performance and well design. The flash separator would separate the steam from the liquid at atmospheric

pressure (about 11.9 psia) and a corresponding temperature of 201°F. The flash separator would be a cylindrical, vertical, open-top vessel, approximately 5-15 feet in diameter and 20-40 feet in height. It is estimated that up to 38% of the total production would be produced as steam at atmospheric pressure, with the remainder as residual liquid. The separated steam would be discharged to the atmosphere. H_2S abatement would be applied if test results indicate potential H_2S emissions greater than 5 lb/hr.

Make-up water would be routed from nearby groundwater wells to the sump or injection pumps to replace any liquid lost to the reservoir or atmosphere. This water would be added to the injection pump suction piping. The make-up water would also provide additional cooling of the bulk fluid flow. Water from the groundwater wells and/or sump would be routed to high pressure injection pumps, then to the injection well, and recirculated through the EGS reservoir back to the production wells.

The equipment would be fully instrumented to provide continuous, real-time data collection and distribution. The system would be sufficiently automated to allow 24/7 supervision and operation by a minimum of two experienced plant operators. The system would be fully self-contained on the S-29 pad, using no external utilities. On site water wells would provide the necessary water and portable diesel generators would provide the electricity required.

Following construction and startup, the system would be operated until steady-state conditions are achieved, or for up to 60 days. Additional data collection would include well logging surveys, geochemistry, and MSA monitoring. The final design of the test system would be highly dependent on the results of injection well stimulation and production well performance. Therefore, the test system design would continue to be refined as results become available. The Proponents would inform the BLM, DOE, USFS and other concerned parties of any design updates or changes.

2.4 Alternative B – Proposed Action with Closed Pressure Vessel and Air Cooled Condensers

Alternative B is identical to the proposed action described in Alternative A except for the long-term circulation test, which uses different equipment. This alternative was derived from public comments received during the scoping process expressing concerns over water usage and the visual impact from the steam plume. In this alternative, closed, pressurized vessels would be used to separate steam at a higher pressure and temperature thereby reducing water lost through evaporation and reducing the amount of water vapor in the steam plume. This alternative would require diesel engines in addition to those in Alternative A to power air-cooled heat exchangers to cool the separated liquid. Details of this final phase of the project are described below.

Long-Term Circulation Test with Pressure Vessels

A 30-60 day circulation test of the injection well and both production wells would be conducted as described above in the Alternative A, the proposed action description. Alternative B deviates from Alternative A in how the steam is separated and cooled.

In Alternative B, the flash separator would be a 66" diameter by 24 ft-long horizontal cylindrical pressure vessel. The separated steam would be routed to diesel-driven electric fan condensers. Figure 10 shows a similar single condensing fan unit prior to installation at the EGS site at Soultz, France. Approximately 200 feet of piping would route steam from the flash separator to the condensing fans. A total of twelve (12) 12-foot diameter fan units would be required. The fan units would be driven by one 40 HP diesel-powered motor for each fan. Two (2) 75 kW diesel-fired generators would be required to power the fans. The diesel generators would consume about 260 gallons of fuel daily, or about 15,600 gallons during a 60-day test. The fans would be approximately 10 ft above grade, installed on semi-permanent concrete foundations. Foundations would require the use of 396 yards of concrete. Installation would require 6-8 weeks more than Alternative A. Four shift workers would be required, including a Lead Supervisor, Mechanic, Electrician, and Steam Plant Operator, to safely operate and maintain the system on a 24/7 basis. Following test completion, the fan system would be dismantled and removed from site, and the concrete foundations would be removed for waste disposal. Figure 11 shows a conceptual configuration of the Alternative B layout on well pad S-29.

Approximately 33% of the total production, or about 400,000 lb/hr, would be produced as steam at 20 psig separation pressure, with the remainder as residual liquid. This separated steam would be routed to diesel-driven electric fan condensers to condense and cool the steam to 180°F. This condensed steam would be routed to the sump or directly to the reinjection pumps. The residual liquid from 20 psig separation would be routed to an atmospheric separator to reduce the pressure before reinjection. About 6% of the liquid will flash to steam and be discharged to the atmosphere (about 43,000 lb/hr) from this separator. The remaining 94% liquid would be routed to the sump or directly to the reinjection pumps.

Figure 10: Cooling Fans Used in EGS Circulation Testing at Soultz, France. Shown Here Prior to Installation, These Would Be Positioned Over or Adjacent to the Heat Exchangers for Operation.

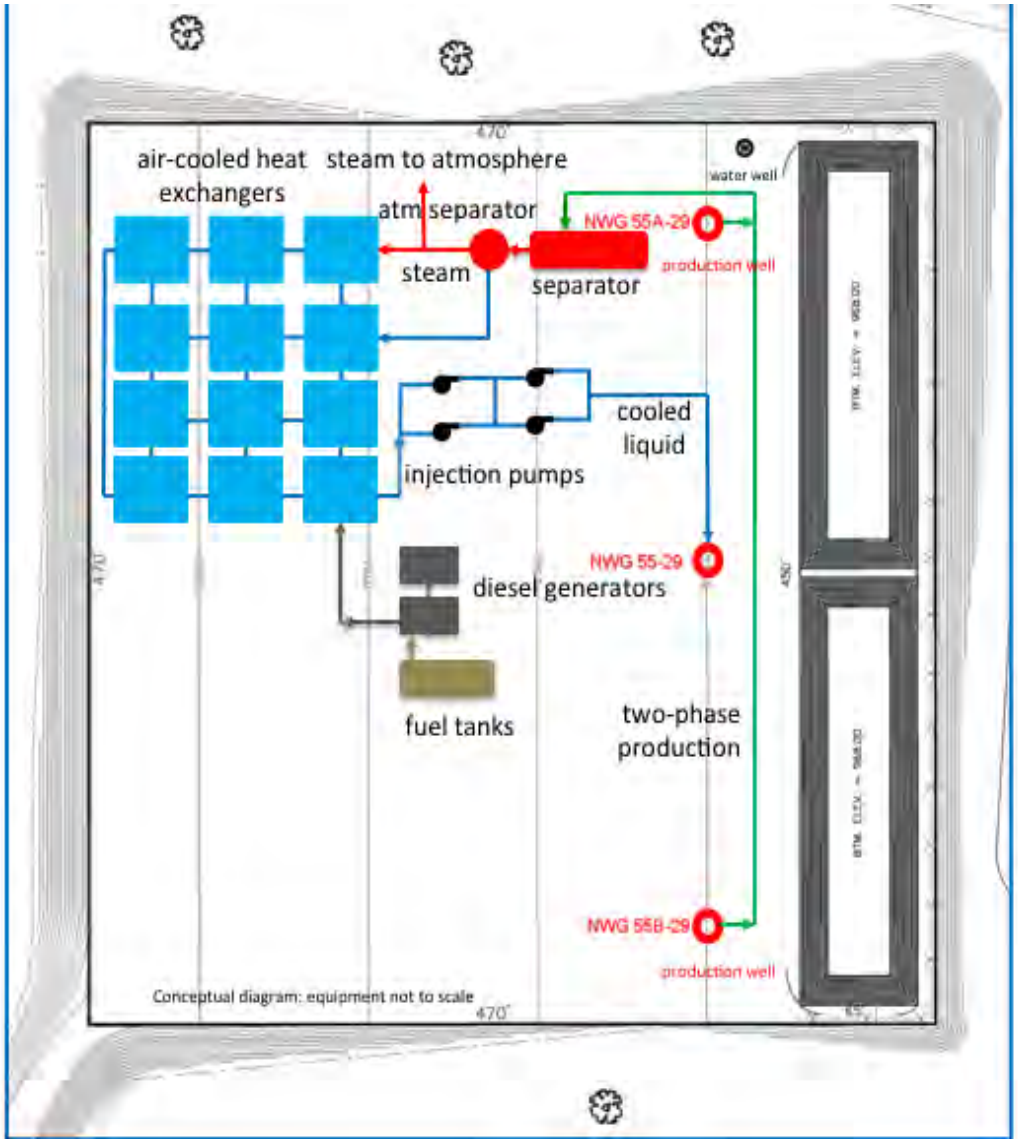

Figure 11: Alt. B-Circulation Test Facility Conceptual Configuration

The residual liquid from the condensers and atmospheric separator would be routed directly to a set of variable-speed injection pumps, or to the sump first and then to the injection pumps. The injection pumps might be arranged in series and/or parallel to provide adequate flexibility in terms of flow rate and injection pressure. Make-up water would be routed from nearby groundwater wells first to the sump or directly to the injection pumps to replace any liquid lost to the reservoir or atmosphere. This water would be added to the injection pump suction piping. The make-up water would also provide additional cooling of the bulk fluid flow. The pump discharge liquid would be returned to the injection well and recirculated through the EGS reservoir, back to the production wells.

As in Alternative A, the final design of the test system will be highly dependent on the results of injection well stimulation and production well performance. Therefore, the

test system design will continue to be refined as results become available and BLM, DOE, USFS and other concerned parties will be consulted.

2.5 Alternative C – No Action Alternative

Under the no action alternative, the EGS demonstration project would not be approved. Analysis of this alternative is required by NEPA to establish a baseline from which to evaluate the relative impact to the environment of implementing other alternatives.

2.6 Project Design Features

The following design features of the Project are incorporated to minimize environmental impacts. A discussion of these specific features is presented below. These project design features are common to all action alternatives and therefore would be implemented for both Alternative A and B.

Wildlife

Field surveys have been conducted by FS for nesting raptors in the area of the new borehole MSA stations (NN17, NN24, and NN19), including the other 17 stations. There are no known active nests within or adjacent to the proposed sites, and the surveys did not detect any raptors. Since human disturbance has been known to potentially cause nest abandonment, the following seasonal disturbance restrictions would be applied if applicable. Since the proposed drilling activities would produce noise that is expected to be heard at ½ mile and the LRMP direction is ¼ mile, and depicts that disturbing activities will vary site specifically, if nesting raptors are located within ½ mile of any of the new borehole MSA sites, a wildlife biologist would make a determination if drilling would be timed to not occur during the breeding season for the following species:

- Bald eagle January 1st – August 31st
- Osprey April 1st – August 31st
- Redtail hawk March 1st – August 31st
- Northern goshawk March 1st – August 31st
- Cooper's hawk April 1st – August 31st
- Sharp-shinned Hawk April 1st – Aug. 31st
- Great gray owl March 1st – June 30th

Noxious Weeds/Invasive Species

Drill rigs, tanker trucks, trailers and any other heavy equipment would be pressure washed in La Pine prior to their first entrance into the project area, and prior to any subsequent entrance after leaving the project area.

The Proponents would be responsible for conducting annual June weed monitoring visits to ensure that weeds do not become established on the drilling or MSA sites. If weeds are found, the Proponents would hand-pull them and bag them if flowers or seeds are present. The Proponent would provide the District Botanist and Special Uses Coordinator of the FS a brief annual report that shows compliance.

The Proponents would be responsible for monitoring the area for two growing seasons after the work is done. For example, if the work is completed in the winter of

2013/2014, the Proponents will monitor in the summers of 2014 and 2015. Weed monitoring would begin the first June after the project has been completed; it is strongly encouraged that the monitoring occurs at this time rather than later in the summer because the weeds would still be small and not flowering or producing seed. The Proponents would be released from further responsibility for weeds within the project area after the second year of monitoring/treatment is concluded.

The annual weed monitoring report would be due no later than September 30, would include descriptions of when they monitored, what weed species, if any, were found, and that they were treated. The report would be submitted to BLM and FS. Hand-pulling would be the treatment. Herbicide application will not be an option for this area, as herbicides have not been approved for use.

Winter Recreation

Timing and Location

Downhole MSA site preparation and drilling would begin immediately upon Project approval by BLM, FS and DOE. This could occur during early 2012 and therefore has the potential to impact winter recreation. The sequence of downhole MSA sites to be drilled is shown in Table 3, starting at NN21 and finishing at NN17. Each site would take approximately 14 days to complete. One truck-mounted rig would be utilized.

The 5 downhole MSA locations and access routes are described in Table 3 below and are listed in the order they would be drilled. The access routes in relation to snowmobile trails are shown in Figure 12 below.

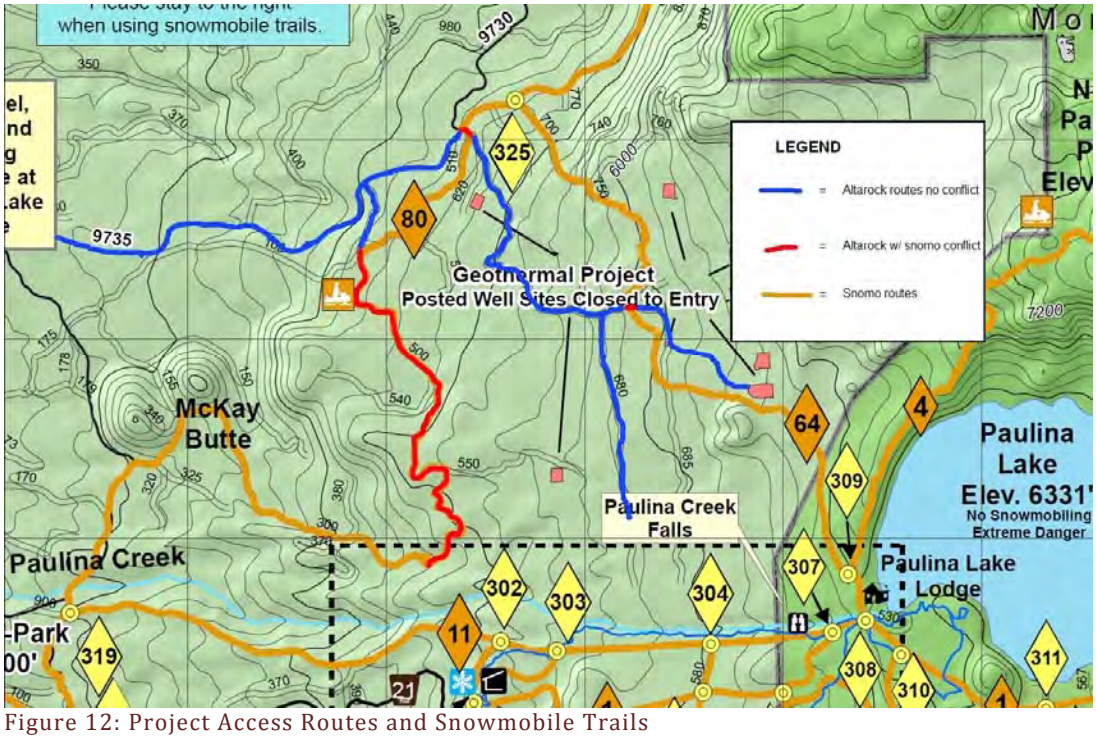

Figure 12: Project Access Routes and Snowmobile Trails

Table 3: Downhole MSA Installation Sequence and Potential for Snowmobile Impact

Priority	MSA Site	Elevation (ft)	FS Road Access	Snowmobile Impact
1	NN21	6,249	9735 to 600 to 685 to 687	Yes
2	NN18	6,033	9735 to 600 to 685	Yes
3	NN19	5,892	9735 to 600 to 680	No
4	NN24	5,933	9735 to 600 to 680	No
5	NN17	5,580	9735 to 500 to 300	Yes

Proposed Design Features to Minimize Winter Recreation Impacts

During the winter season, signs would be posted at appropriate snow parks, and other principal entrance points providing winter access to NNVM, warning that geothermal and other activities, when combined with weather and snow conditions, could trigger avalanches.

Because drilling activity would occur during the winter snowmobile season, active snowmobile trails that follow Forest roads needed to access Project sites would be groomed by the La Pine Lodgepole Dodgers snowmobile club with a snow grooming machine rather than being plowed with a blade. Snowmobile Trail 80 overlaps with Forest Road 500, which is necessary to access NN17. This is the longest section of trail that overlaps a required access road. The snow would be groomed to a depth of a few inches, leaving a rutted surface that is drivable by both trucks and snowmobiles. Where Trail 80 crosses Forest Roads used for the project in the winter, the grooming machine would build and maintain snow ramps to facilitate snow machines entering and exiting the road crossing. If this does not provide a safe surface for the truck mounted drill rig to drive on, some areas may be plowed to provide access with FS approval. A minimum of 2" of snow depth would be left to protect the roadway and allow snow mobile access. Appropriate signing meeting MUTCD standards would be placed to warn winter users of the change in the trail condition due to vehicle traffic.

If stimulation occurs in the winter, the Proponents would provide information on Project activities to the Central Oregon Avalanche Association (www.coavalanche.org) for their weather and warnings page, with a link to the project website.

Induced Seismicity

The DOE requires that EGS demonstration projects throughout the U.S. meet or exceed the International Energy Agency (IEA) *Protocol for Induced Seismicity Associated with Geothermal Systems* (Majer et al., 2008). The protocol includes a number of steps including the preparation of an induced seismicity mitigation plan. That mitigation plan, *Induced Seismicity Mitigation Plan for the Newberry EGS Demonstration* (AltaRock Energy Inc., 2011), is included in Appendix A.

The induced seismicity mitigation plan describes in detail the operational procedures, proposed controls and mitigation actions that will be implemented to mitigate any

potential effects of induced seismicity from the Project. A summary of the key induced seismicity mitigation measures is presented here. The reader is directed to the detailed Plan included in Appendix A for in depth details of the plan.

Dimensions of the EGS Reservoir

The goal of the demonstration project is to create a sustainable EGS reservoir measuring approximately 3,280 ft. (1000 m) horizontally with a vertical growth limit set at a depth of 6,000 ft. (~1.8 km). Setting a vertical growth limit of 6,000 ft. would provide a buffer of 5,000 ft. (1.5 km) of impermeable rock between the EGS reservoir and local groundwater resources (Figure 13).

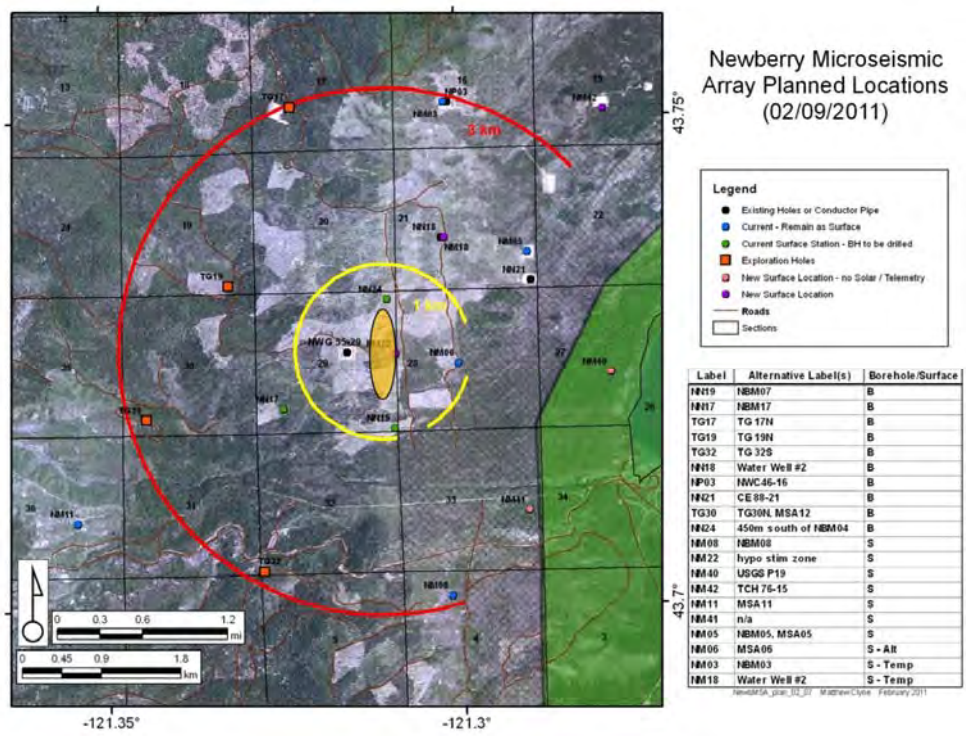

Figure 13: Final MSA, Including Borehole Installations, Shown In Relation To Planned Stimulation Zone. Ellipse With 1 Km North-South Major Axis, Centered Over The Middle Of The Open-Hole Interval, Is Current Prediction Of The Microseismicity Cloud That Would Be Induced And The Approximate Extent Of The EGS Reservoir, Based On A Preliminary Stress Model. Multiple Zones Will Have Different Depths, But Roughly The Same Map View. Hatched Area Is Special Management Area (No Surface Occupancy) Adjacent To NNVM, Shown In Green. Even If The EGS Reservoir Grows In An Unexpected Direction (Not North-South), The Map Shows Sufficient Room For An EGS Reservoir Of Any Orientation Around NWG 55-29.

Initial modeling and experience at other EGS projects suggests that microseismicity will be clustered within a 500 m radius of the injection well and grow outward as the injected fluid opens connected fractures. For this demonstration Project, an "outlier" is defined as any seismic event between 1 and 3 km from the midpoint of the open-hole interval of 55-29. This is the area between the yellow and red circles and shown in cross-section in Figure 14. Events that might occur beyond 3 km cannot be reliably

located by the MSA, but events greater than M 2.0 in this area would be detected by the regional network.

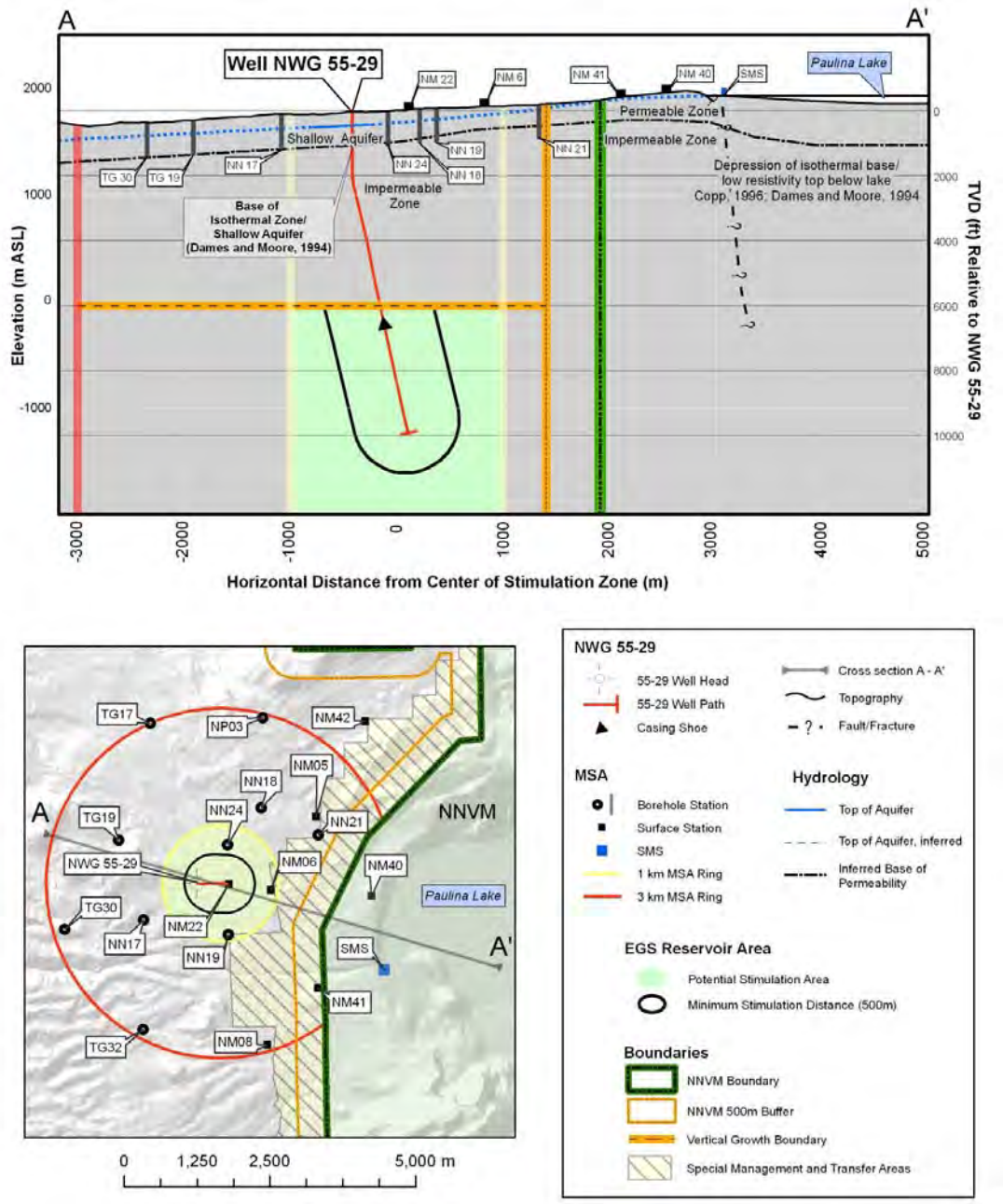

Figure 14: Cross-Section and Map Showing Expected EGS Reservoir Area, MSA and SMS Station Locations, Horizontal and Vertical Growth Limits, and Trigger Boundaries.

The Newberry National Volcanic Monument boundary is about 2.3 km (1.4 mi) from the wellhead of NWG 55-29 and 1.8 km from the bottom of the well. Thus, there is 800 m (0.5 mi) between the closest edge of the nearest possible EGS reservoir and the monument. However, because of special concern by the BLM and FS, a special, more aggressive mitigation action is designated for confirmed outliers within 500 m (1640 ft)

of the Newberry National Volcanic Monument [12]. While models predict that horizontal errors up to 400 m are possible, even with a 400 m error, the 500 m buffer will protect rocks under the Monument from being affected.

Seismic Monitoring

The MSA would be used to constantly monitor the growth of the EGS reservoir during the hydroshearing operations. A chief seismologist would prepare daily activity reports for transmittal to the DOE, BLM and others showing seismic event magnitudes plotted versus depth and distance from the stimulation well NWG 55-29. These reports would be transmitted to designated third parties (e.g., DOE and BLM) by 11:00 am each day. Contacts to be notified of operational schedules, activities, daily reports and exception reports are listed in Table 4 below.

Table 4: Contacts For Induced Seismicity Communications

Organization	Contact Name	Email Address	Phone
Technical Notification and Review: Outlier, Trigger, and Mitigation Reports			
Pacific Northwest Seismic Network (PNSN)	John Vidale	john_vidale@mac.com	(206) 543-6790
U.S. Department of Energy (DOE)	Eric Haas	eric.hass@go.doe.gov	(303) 275-4728
Lawrence Berkeley National Lab (LBNL)	Ernest Majer	elmajer@lbl.gov	(510) 486-6709
U.S. Bureau of Land Management (BLM)	Linda Christian	linda.christian@blm.gov	(541) 416-6890
U.S. Forest Service (FS)	Rod Bonacker	rbonacker@fs.fed.us	(541) 549-7729
Emergency Notification: Seismic Event Reports			
Deschutes County Sheriff	Dispatch	NA	(541) 693-6911
Central OR Interagency Dispatch Center	Duty Officer	NA	(541) 416-6800 1-800-314-2560
Deschutes NF Supervisors Office	Front Desk	NA	(541) 383-5300

Flow Back to Reduce Reservoir Pressure and Seismicity

One significant difference between the injection strategy at the Newberry EGS Demonstration and prior EGS projects is the manner in which the excess pressure created by injection would be reduced. In this Project, the well would be flowed to pre-installed surface test equipment immediately after hydroshearing is completed to

[12] See Trigger and Mitigation Action #2 discussed below and in Section 5.3 (p. 48) of the ISMP attached in Appendix A.

relieve reservoir pressure. Reducing reservoir pressure is expected to decrease the fluid pressure in the EGS reservoir and reduce post-hydroshearing induced seismicity.

Prior to stimulation of NWG 55-29, at least eighteen water storage tanks would be installed on Pad S-29. Each tank holds 22,000 gallons of water. The existing groundwater wells, one on Pad S-29 and one on Pad S-16, would flow directly into the tanks via above-ground, temporary piping. Thus, the tanks would provide a 396,000 gallon volume buffer and allow the double-lined sumps on both pads to remain empty. The suction-side of the injection pumps would pull directly from the storage tanks and inject into NWG 55-29. The flow back fluid handling equipment, which consists of a flow line, flow control valve, instrumentation, James tube assembly, atmospheric separator and weir box, would be connected to the master valve on NWG 55-29 during the entire stimulation treatment. If a seismic event occurs that requires the most aggressive mitigation action the well would be immediately flowed back by shutting down the injection pumps and closing the valve on the injection line. The valve on the flow line would then be opened, and the well would be allowed to flow through the separator and weir box and into the empty sump on Pad S-29.

The water would travel from the wellhead through the flow line and control valve into the James tube assembly. The fluid would then be separated into two phases, liquid water and steam, with an atmospheric separator (Figure 15). The steam discharges vertically and the water is funneled into an outlet at the bottom of the separator. From that point, the liquid flows through the weir box where the flow rate is determined by measurement of the height of the liquid flowing through a V-notch weir. Hence, the liquid and steam flow rates would be measured and calculated separately so that total fluid flow and two-phase enthalpy could be calculated. The weir box discharges into the sump on Pad S-29. If the Pad S-29 sump begins to approach capacity (1.4 million gallons), redundant, high-head transfer pumps would be in position to transfer water from the sump on Pad S-29 to the sump on Pad S-16 through the temporary piping. For redundancy, each pump would be capable of pumping 1,000 gpm of water uphill to Pad S-16, which is 362 feet higher in elevation than Pad S-29. Effectively, the two sumps would provide about 2.8 million gallons of geofluid storage capacity during the flow back operations. This is approximately 12% of the maximum estimated water usage for the 21-day stimulation.

Figure 15: Wellhead, Flow Line, Control Valve, James Tube and Atmospheric Separator Used in a Geothermal Well Flow Test in Nevada, Similar to, but Smaller Than the Separator to be Used At Newberry.

At estimated production rates, the initially empty Pad S-29 double-lined sump would have sufficient capacity for approximately 70 hours of maximum liquid water flow, representing 11.6% of the injection stimulation water, which is expected to be 24,192,000 gallons if an injection rate of 800 gpm is applied for 21 days. If the well flow approaches the sump capacity, while still allowing an adequate freeboard of two feet, additional produced liquid would be transferred to the double-lined sump on Pad S-16, which provides for a similar flow duration and capacity. Another system safeguard is the flow line valve, which can also be partially closed to reduce the production rate if water carry-over from the atmospheric separator or the weir box is becoming a concern or if the sumps are nearing capacity. Water discharged to sumps would be removed by one of several methods. Whenever possible, water would be reinjected into the EGS reservoir. If the injection well is unavailable, and prior chemical analysis of sump liquid indicates the water composition has not changed significantly and it has been determined to be beneficial, water may be sprayed over the nearby forest, or spread over roads and well pads for dust control. Otherwise, water would be evaporated using spray systems positioned over the sumps.

Growth, Magnitude and Shaking Limits

Mitigation actions will be triggered when induced seismicity exceeds predefined limits in any one of the following three categories:

1. EGS reservoir growth toward undesirable locations,
2. seismic event magnitudes in the reservoir that could lead to larger events or,
3. shaking that could disturb visitors to the NNVM.

For each category, there are intermediate levels designed to proactively manage potential problems. The limits are described first below. How the limits are used to trigger mitigation actions is discussed subsequently.

- Horizontal Growth Limits

  In the simplest case, the 1000 m long EGS reservoir will be centered on the well (500 m in each direction); however, it is also possible that the EGS reservoir will grow primarily in one direction, in which case a perimeter of up to 1000 m (3280 ft) from the well is appropriate to allow creation of an adequate size reservoir (Figure 14). Microseismic events further than 1000 m from the well will be considered outliers.

- Vertical Growth

  A seismic event with M>1.0 or that can be picked on 6 or more MSA seismograms and is located shallower than 6000 feet (1.8 km) below the ground surface at NWG 55-29 may indicate that the reservoir is growing shallower than desirable. This depth defines the minimum desired temperature of the EGS reservoir and maintains at least 5000 feet (1.5 km) of impermeable rock between the EGS reservoir and local groundwater resources.

- Magnitude less than 2.0

  Most, and possibly all, seismic events will be smaller than M 2.0. Fugro (2011) determined the probability of generating an M > 2.0 event is between 0.1%-6.0%; the probability of larger events is orders of magnitude lower. At Fenton Hill, an EGS project conducted in a similar geologic setting, the largest events were M 0.0. Because of the way seismic event distributions follow the Gutenberg-Richter law, if there were one M 2.0, there will be on the order of ten M 1.0, and a hundred M 0.0. This would result in a successful EGS demonstration. Seismic events with M < 2.0 will not be considered a concern unless they indicate growth of the EGS reservoir into undesirable locations.

- Magnitude between 2.0 and 2.7

  Induced seismic event with M ≥ 2.0 would be similar in size to the few natural microseismic events recorded nearest NWG 55-29. In addition, our study of the Basel EGS project (Section 3.7) indicates that M ≥ 2.0 events, the first of which occurred 2 days before the main M 3.4 event, and an additional four events that occurred within 16 hours of main event, were warning signals that were ignored by those operators.

- Magnitude between 2.7 and 3.5

  An M 2.7 seismic event releases seismic energy equivalent to about eleven (11) M 2.0 events (see Section 2.2). This magnitude is close to midway between the lower limit

(2.0) and upper magnitude limit (3.5), and thus provides an alert before reaching the upper bound limit of M 3.5. In addition, at this level events that occur outside the perimeter of the MSA are reliably located by the regional network. Fugro (2011) concluded that the probability of an M > 3.0 event during the Demonstration is 0.01%-0.8%.

- MAGNITUDE GREATER THAN OR EQUAL TO 3.5

  Wong et al. (2010) estimated that the upper-bound range of maximum magnitudes for induced events would range from magnitude M 3.5 to 4.0. Seismic events larger than M 3.5 are not desirable, likely or expected, but are possible; events at or above this magnitude will result in the most aggressive mitigation actions. Fugro (2011) concluded that the probability of an M > 4.0 event during the Demonstration is 0.002%-0.09%.

- MEASUREMENTS ON PLVC-SMS

  Triggers based on measurement of peak ground acceleration (PGA) at the Paulina Lake Visitor Center SMS are intended to be proactive, triggering actions at shaking levels below which most visitors will notice, and well below levels of potential damage. The instrument-measured shaking on PLVS-SMS must be correlated in time to a microseismic event to prevent false positives caused by cultural noise. Because perceived shaking and damage due to PGA from EGS induced seismicity is thought to be lower than for natural events (Majer et al., 2007), these PGA triggers are considered to include large margins of safety.

- PEAK GROUND ACCELERATION BELOW 0.014 G

  Below a PGA of 0.014 g, shaking is considered "weak". PGA < 0.014 g corresponds to a MMI Level III, which is equivalent to "vibrations similar to the passing of a truck." Visitors to Paulina Lake regularly experience this level of seismic disturbance due to passing recreational vehicles, delivery trucks, loud motorcycles, and, in the winter, snowmobiles. The cautious shaking model of Wong et al. (2011) implies that an M 2.7 event at the well would produce shaking less than 0.014 g at PLVC. There is no potential for damage at this level of shaking.

- PEAK GROUND ACCELERATION BETWEEN 0.014 G AND 0.028 G

  Above a PGA of 0.014 g, shaking is considered "light". PGA between 0.014 g and 0.039 g corresponds to a MMI Level IV which is equivalent to "sensation like heavy truck striking building." There is no potential for damage at or below MMI Level IV. Wong et al. (2011) suggests that shaking at this level could trigger snow avalanches. FS has also expressed concern that, like snow avalanches, rock fall on talus slopes could be triggered by light shaking.

- PEAK GROUND ACCELERATION GREATER THAN OR EQUAL TO 0.028 G

  Twice as much shaking as the previous limit but still within a level perceived as "light" and the potential for damage is "very light" (MMI Level IV). The cautious shaking model of Wong et al. (2011) implies an M 3.0 event could occur at the well and produce shaking less than 0.028 g.

Exception Reports

The operational center will be staffed by seismologists who will refine waveforms auto-picks, improve event locations, and track maximum event size and the size distribution of microseismicity (the b-value) 24 hours a day. The daily report, transmitted at 11:00 am daily, is described in Section 4.5 of the ISMP (Appendix A). Here we briefly describe the additional reports that will be prepared and transmitted to DOE, BLM, FS, PNSN and LBNL when exceptions occur:

- Outlier Reports

  An outlier report will document the location and waveforms of any seismic event picked on 6 or more stations that is initially located outside of the expected stimulation zone (i.e., >1000 m from the well or shallower than 6000 ft). The report will include all relevant information about the seismic event (location, size, time, number of picks, quality of picks, etc.) and stimulation conditions (e.g., flow rate, wellhead and downhole pressure, temperature profile). The report will document whether the outlier was confirmed or relocated by additional analysis. If the event is confirmed as an outlier, the mitigation action will be described. The report will be transmitted to the DOE, BLM, FS and LBNL within 2 hours after the outlier has been initially identified and the mitigation action initiated.

- Trigger Reports

  A trigger report will document that a magnitude or shaking trigger has been exceeded. The report will include all relevant information about the seismic event (e.g., location, size, time, number of picks) and stimulation conditions (e.g., flow rate, wellhead and downhole pressure, temperature profile). The report will document whether the event was felt by anyone on the drill pad or reported by the public, and what mitigation action was initiated. The report will be transmitted to the DOE, BLM, FS and LBNL within 2 hours after the trigger occurs.

- Seismic Event Phone Calls

  For the higher magnitude and shaking levels, initial notification will be made by phone to inform the key personnel at the organizations listed in Table 4-3. Calls will be made by the on-duty site supervisor as soon as the event is reviewed by a seismologist, and in no case more than two hours after the event. A trigger report with details of the event analysis and mitigation actions will follow the phone alerts.

- Mitigation Reports

  After sufficient time has passed to evaluate the efficacy of a mitigation action, a summary report will document actions that were taken, and the seismic and well response.

Triggers and Mitigation Actions

- Confirmed Outlier

  A confirmed outlier with a magnitude greater than or equal to 2.0 will result in the use of diverter to shift stimulation to another zone. A confirmed outlier with a magnitude less than 2.0 will require a second confirming event (of any locatable magnitude) to trigger use of a diverter. Any planned increase in flow rate will be postponed until after the diverter is applied. The MSA radius is 3 km, making location and magnitude determination for events outside this area unreliable. Larger magnitude events can be detected by the PNSN regional network. For outliers exceeding the M 2.7 and M 3.5 magnitude triggers, the mitigation action for the magnitude limits will be used.

- Outlier within 500 m of NNVM

  Any confirmed outlier within 500 m (1640 ft) of the NNVM boundary will result in the use of diverter to shift stimulation to another zone. Any planned increase in flow rate will be postponed until after the diverter is applied.

- Unwanted Vertical Growth

  Any seismic event with M > 1.0 or that is picked on 6 or more stations of the MSA that is located shallower than 6000 feet (1.8 km) below the ground surface at NWG 55-29 will result in use of diverter to shift stimulation to another zone. Any planned increase in flow rate will be postponed until after the diverter is applied.

- Incomplete Diversion and Failure to Mitigate

  After the decision to use diverter is made it may take up to 4 hours to prepare the diverter and apply it at the depth where diversion is required. Two diverter applications may be necessary to completely seal a fracture zone. Therefore, 8 hours may be required to determine whether diversion has succeeded. If growth into an undesired location continues eight hours after the event that triggered the diversion, the flow rate will be decreased as described below in Mitigation Action 6.

- No Flow Rate or Pressure Increase

  The stimulation plan is to increase flow rate every two hours as long as the seismic response is safe and the pressure remains lower than formation tensile failure and casing burst pressures. However, the flow rate and wellhead pressure will not be increased for at least 24 hours if one or more events with M greater than or equal to 2.0 and less than 2.7 are located within the MSA radius (3 km). If a constant flow rate is leading to increasing pressure, keeping the wellhead pressure from increasing might require reducing the flow rate. Wellhead pressure increased at a constant flow rate of ~450 gpm during the fifth day of the Basel DHM-1 project, indicating a build-up of pressure in the EGS reservoir that was a possible precursor to M_L > 2.5 seismic events (Figure 3-8 and Section 3.5 of the ISMP).

- Decrease Flow Rate and Pressure

  Any ground motion recorded on the Paulina Lake SMS with a PGA greater than 0.014 g that can be correlated in time to a seismic event will result in a reduction of flow rate. In

addition, any seismic event with M greater than 2.7 and less than 3.5 and occurring within the 3 km (1.9 mi) radius of the MSA, as determined by the PNSN regional network or the MSA, will also result in a reduction of flow rate. The injection rate will be decreased so that the downhole pressure is reduced by 250 psi. If events with M greater than or equal to 2.0 continue to occur, the injection rate will be further decreased to achieve an additional 250 psi reduction. If more than 24 hours passes without M > 2.0 events, the flow rate may be gradually increased over a 24 hour period back to the rate prior to the triggering event. Beginning at this action level, instructions to report damage will be made available on the project websites. In addition to the written trigger reports, phone calls will be made to inform key personnel at the Technical Organizations and local Emergency Dispatch listed in Table 4. In cooperation and prior agreement with FS, AltaRock will notify park visitors, users of Road 500 to Paulina Peak, and owners and users of NNVM assets (e.g., lodges and cabins) regarding the potential for induced seismicity, shaking, slope instability and other possible disturbance, and limit access to certain areas as agreed in advance with FS personnel.

- STOP INJECTION AND FLOW WELL

  Any ground motion recorded on the Paulina Lake SMS with a PGA greater than 0.028 g that can be correlated in time to a seismic event within the 3 km (1.9 mi) aperture of the MSA will result in injection being halted. In addition, any seismic event detected within the 3 km (1.9 mi) aperture of the MSA with M greater than 3.5 as determined by PNSN or the AltaRock MSA, will also result in injection being halted. After injection is stopped, the well will be immediately flowed to surface test equipment to relieve reservoir pressure (see Section 4.6 of ISMP). Sufficient sump capacity will be available to store at least 10% of the injected fluid. Resumption of stimulation will be made only after consultation and agreement between AltaRock, DOE, BLM and FS. In addition to the written trigger reports, phone calls will be made to inform key personnel at the Technical Organizations and local Emergency Dispatch listed in Table 4. In cooperation and prior agreement with FS, AltaRock will notify park visitors, users of Road 500 to Paulina Peak, and owners and users of NNVM assets (e.g., lodges and cabins) regarding the potential for induced seismicity, shaking, slope instability and other possible disturbance, and limit access to certain areas as agreed in advance with FS personnel.

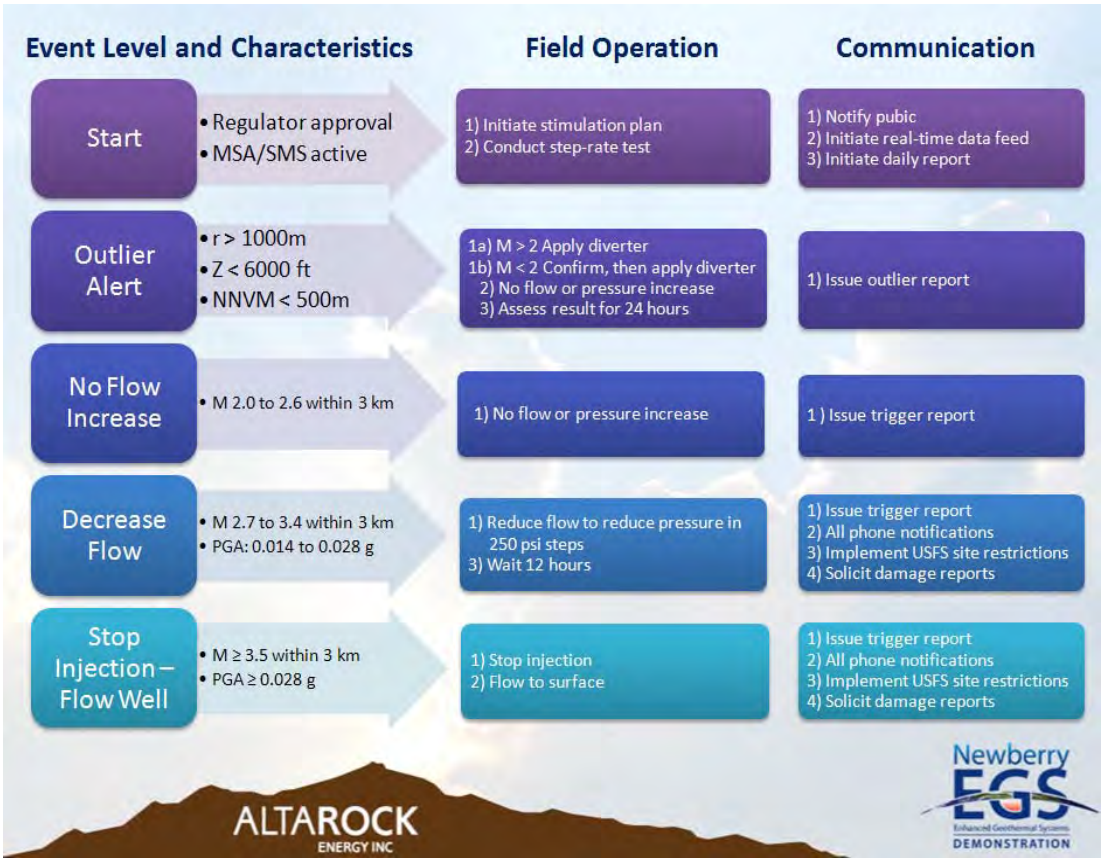

Figure 16: Decision Tree for Triggers and Mitigation Actions

Indirect Mitigation

The mitigation steps above are designed to minimize the likelihood of damage to structures, slopes and other assets in the NNVM. The Proponents believe that the safeguards and mitigation controls described above are based on the best possible science and engineering available prior to stimulation. However, because the history of EGS projects is limited and the seismic response of the rock volume surrounding NWG 55-29 cannot be predicted with complete certainty, no guarantee can be made that no damage will occur. Therefore, the Proponents also developed indirect mitigation plans for unlikely or worst case results.

- Damage to structures

If shaking measured by the SMS reaches PGA > 0.05 g (Appendices I and J of the ISMP), it is possible that some cosmetic damage could occur to structures near Paulina Lake. Instructions and a tentative form to report damage have been developed (attached as Appendix J of the ISMP) and will be made available on the project websites[13] and to

[13] www.newberrygeothermal.com; www.altarockenergy.com

owners and users of NNVM assets. If stakeholders notice new damage to the cabins, buildings, roads, or the dam after a felt, induced event occurs, they will be instructed by the project hotline, web sites and printed notifications to NNVM asset owners to submit the damage report within two months of event. A licensed, independent civil engineer, selected with the concurrence of all stakeholders, will evaluate all claims and compare any information collected prior to stimulation (see Section 3.6 of ISMP) to the potential damaged condition, as well as the shaking recorded on the PLVC SMS, and the magnitude of the relevant induced seismic event. Payment for repairs will be based on engineering standards and the measured or inferred shaking, and whether the damage could have been caused by a demonstration project seismic event or events.

A similar approach has been used by the Geysers Seismic Monitoring Advisory Committee in Middletown, CA where about 10 M > 3.0, and 1-2 M > 4.0, seismic events occur per year due to geothermal production and injection[14]. In the town of Anderson Springs, houses and cabins are very close (within 1 km) to the geothermal operations. Damage claims are evaluated by the Committee to evaluate the validity and value of damage compensation. Between 2004 and 2009, funds were approved by the committee for repairs to 19 properties totaling $63,299[15]. If long term operation ever occurred at Newberry a committee might be appropriate. For a quick response to an unlikely event, DOE considers an independent expert more appropriate for the short term Newberry EGS Demonstration.

- Emergency Plans for Road Damage and Closures

  Some roads in the NNVM, particularly Road 500 to Paulina Peak, are quite steep and cross beneath slopes prone to rock fall or avalanche. Although it is unlikely that roads will become blocked by a seismicity-triggered rock fall (it is closed in the winter season), this possibility cannot be ruled out. Therefore, the Proponents have developed the following plan to mitigate this risk during active field operations, including stimulation and flow testing.

  Signs will be posted at the beginning of Road 500 for uphill traffic, and on Paulina Peak for downhill traffic, stating “Rock fall hazard ahead. Please contact 855-EGS4USA toll-free (855-872-4347) to report rocks on the road,” or alternative text approved by the FS. The Proponents will work with FS to ensure that the signs are in place two weeks before

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14 http://www.andersonsprings.org/EarthquakeCharts/smacnov2009stronggroundmotionanalysis1.pdf

the stimulation and remain in place until at least the end of the three-well circulation flow test.

A front-end loader and equipment operator will be contracted in advance and on standby in La Pine, ready to remove any debris that falls onto roads from steep road cuts after a felt seismic event. FS will be notified and will approve of any plans prior to work commencing.

Arrangements will be made for a road flagging team to be available to control traffic during any partial or full road closure, or during cleanup of the road by the loader.

During and for at least two months after the stimulation and flow testing, response will be within 2 daylight hours after a slide is reported.

- Snow Avalanche Warnings

  If stimulation or flow test activities are conducted during the winter, visitors to the area will be warned of an increased risk of snow avalanches (Wong et al., 2011).

  Signs will be posted at snow parks and other entrance points that provide winter access to NNVM. The signs will read "Warning: snow avalanche hazards exist on any slope steeper than 25°, including the slopes leading to Paulina Lake and East Lake from the Crater Rim. Skiers and snowmobilers, and geothermal demonstration activities occurring this winter can trigger avalanches on hazardous slopes. Call 855-EGS4USA toll-free (855-872-4347) for more information", or alternative text approved by the FS. AltaRock will work with FS to ensure that these signs are in place two weeks before the stimulation and remain in place until at least the end of the three-well circulation flow test.

- Insurance

  The Proponents have obtained both general liability and umbrella liability insurance under which a third party may collect if the Proponents are found liable for damage caused by induced seismicity. AltaRock's Commercial General Liability Insurance with the Federal Insurance Company, a subsidiary of the Chubb Group of Insurance with an A.M. Best Rating of A++, has a general aggregate limit of $2,000,000 and a $1,000,000 limit for each occurrence. The General Liability Policy covers bodily injury or property damage that AltaRock becomes legally obligated to pay by reason of liability. The General Liability Policy does not include an exclusion for "subsidence" which is defined as bodily injury or property damage arising directly or indirectly out of, caused by, resulting from, contributing to or aggravated by "subsidence, settling, sinking, slipping, falling away, caving in, shifting, eroding, mudflow, rising, tilting or any other movement of land or earth." AltaRock also has Umbrella Liability Insurance with the Federal Insurance Company with a general aggregate limit and occurrence limit of $5,000,000.

2.7 Alternatives Considered but Eliminated from Further Analysis

Three alternatives were analyzed for the purpose of this EA: Alternative A, the proposed action; Alternative B, the proposed action with closed pressure vessel and air cooled condensers; and Alternative C, the no action alternative. One other alternative was considered but eliminated from further analysis.

Pad S-16 Location

BLM also considered the possibility of locating the Project on Pad S-16 instead of on Pad S-29. Pad S-16, constructed by Davenport in 2008, is located approximately 2 miles northeast of pad S-29 in an area designated as general forest (MA-8) in the Forest Plan, whereas pad S-29 is located in the scenic views area (MA-9). Locating the Project on pad S-16 would not have substantially reduced visual impacts, and it raised a number of problems. Well NWG 46-16, located on pad S-16, developed an obstruction at 4,568 feet, in the cased interval, when last entered, and a complete blockage at 5,106 feet, indicating unstable formation at this depth. It is possible that this well cannot be repaired. It would not be possible to determine whether this well could be made mechanically competent without mobilizing a drilling rig, removing the blockage, then determining the cause of the well bore failure. Removal of the blockage and repair of the well, if at all possible, would have required mobilization of a drill rig for 30-60 days to complete the repair. Having a drill rig on site for an additional 60 days would increase diesel fuel and water consumption as well as increase traffic and visual impact. Following removal and repair of the blockage, additional surveys would be required to determine whether this well exhibited the appropriate geological conditions conducive to EGS stimulation. These significant additions to the project schedule would result in a project completion date that exceeds that specified by the Department of Energy for this demonstration. Well NWG 46-16 is only cased and cemented to 4,742 feet while NWG 55-29 is cased to 6,462 feet. This additional 1,720 feet of cement and casing at NWG 55-29 allows for stimulation to occur at a greater depth and provides better groundwater protection. In addition, background data collection similar to that already completed at NWG 55-29, including MSA installation, calibration and monitoring, baseline injectivity testing, and temperature and borehole televiewer surveys would need to be conducted to ensure that the well integrity has not been compromised and that the well would be an acceptable candidate for stimulation. Finally, the borehole MSA array would not have been able to take advantage of as many existing well sites, and would have required more ground disturbance as a result. Due to these factors and the technical problems in the wellbore at well NWG 46-16, BLM determined that conducting the demonstration Project at NWG 46-16 would not be feasible.

No other alternative locations were considered because there are no other existing deep geothermal wells in the project area.

2.8 Comparison of Alternatives

Table 5 provides a summary comparison of the alternatives. For more detailed descriptions of the affected environment and the effects of the alternatives, please refer to Chapters 3 and 4.

Table 5: Comparison of Alternatives and Key Issues

Resource	Unit of Measure	Alt. A: Proposed Action	Alt. B: Air Cooled Condensers	Alt. C: No Action
Wildlife	Area of habitat removed	3 sites, 28,125 square feet (2/3 acre) total	3 sites, 28,125 square feet (2/3 acre) total	0
Scenic Resources	Number of sites and size of areas that would have vegetation removed sufficient to be seen from designated viewpoints	3 sites, 28,125 square feet (2/3 acre) total	3 sites, 28,125 square feet (2/3 acre) total	0
Scenic Resources	Size and Density of Steam Plume	40 feet to 930 feet in height	40 feet to 930 feet in height, less vapor, lower density	0
Water Usage	Total amount of groundwater to be withdrawn	Maximum of 141.7 million gallons	Maximum of 74.8 million gallons	0
Induced Seismicity	Probability of exceeding PGA above 0.028 g[16] due to EGS activities	0.2 %	0.2 %	0 %[17]

[16] 1 g is the acceleration due to gravity. A PGA of 0.028 g corresponds to a class IV MM Intensity level, perceived as "light shaking" by USGS standards.

[17] Note: The probability that natural seismic or volcanic events will produce shaking that exceeds 0.028 g is 5 % per year (URS, 2010)

CHAPTER 3. AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This chapter describes the environment that could be affected by the proposed Project. It serves as a basis for discussion of environmental impacts and consequences of the three alternatives which will be discussed in Chapter 4. The discussion of the affected environment is prepared to a level of detail that is commensurate with the potential for environmental impacts to each resource.

3.2 GENERAL SETTING

The Project area is located on the western flank of Newberry Volcano, outside the Newberry National Volcanic Monument (NNVM) and within the Bend-Fort Rock District of the Deschutes National Forest. The project area is adjacent to (but not within) the NNVM.

Newberry Volcano is a broad, gently sloping, shield-like, forested landform that rises approximately 3,600 feet above the surrounding terrain. With an area in excess of 500 square miles, it is among the largest Quaternary volcanoes in the conterminous United States and the largest in Oregon. The terrain is made up of pressure ridges, tumuli, and gently to moderately sloping high lava plains. The habitats through the project area consist predominately of dry pine forest (lodgepole and ponderosa) of various age classes with a few white fir mixed throughout. Manzanita, *Ceanothus. sp* and several species of currant make up the deciduous shrub understory at most sites with grasses, forbs, conifer duff, and other downed woody material comprising the ground cover.

A history of fire exclusion and logging has altered the forest vegetation in the area from what may have occurred historically. There are numerous Forest Service roads in and around the project vicinity that were constructed and maintained for forest management, timber sales, recreation access, and general public or commercial uses. There are user created roads in the area as well.

The primary site for the proposed project is well pad NWG 55-29. This is a well pad that was permitted by BLM and FS and constructed by Davenport in 2008. The pad is approximately 5 acres in size, level, and surfaced with crushed rock. The pad is graded such that any runoff is directed to an approximately 1.5 million gallon double-lined sump. There currently is a groundwater supply well and a deep geothermal well (NWG 55-29) on the pad. The well pad was designed and permitted by BLM and FS to safely accommodate up to three deep geothermal exploration wells. Access to well pad NWG 55-29 is via Forest Road (FR) 9735 to FR 600 to FR 685. These Forest Service roads have been improved and maintained to provide safe access for large vehicles and drill rigs to the site.

3.3 Resources Brought Forward for Analysis Based on Key Issues

As described in Chapter 1.8 and 1.9 - Scoping and Identification of Issues, relevant issues to be carried forward, addressed, and analyzed in Chapters 3 and 4 include the following resources.

3.4 Wildlife

A Forest Service biologist conducted a wildlife report and Biological Evaluation (BE) to address the potential effects from the proposed project on the following species: federally threatened, endangered, candidate, or proposed species (TEPC); Region 6 sensitive species; Management Indicator Species [LRMP, (MIS)]; the US Fish and Wildlife Service (FWS) Birds of Conservation Concern (BCC), Focal Bird Species, and High Priority Shorebirds (shorebirds), including the components of these species' habitats.

These documents meet the direction provided by the Forest Service Manual (FSM 2600), the Deschutes National Forest Land and Resource Management Plan (LRMP) [1990] as amended by the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (Northwest Forest Plan) [1994] and/or as amended by the Environmental Assessment for the Continuation of Interim Direction Establishing Riparian, Ecosystem and Wildlife Standards for Timber Sales (referenced as the "Eastside Screens"; USDA, 1995), and the Endangered Species Act (ESA) of 1973.

The BE concluded that there is no suitable habitat for Northern spotted owl or Oregon spotted frog within or adjacent to the project area.

There is no denning habitat for wolverine within or adjacent to any of the existing or proposed sites. There is potential denning habitat further east/northeast in the greater Newberry Crater. The eastern flanks of the crater are undeveloped with no roads and the crater itself (Paulina Peak, East and Paulina Lakes) has the high elevation and talus habitat utilized by wolverines. However, these landscapes are relatively small and do not contain large blocks of contiguous habitat. In addition, parts of the crater are heavily utilized by humans (snowmobiles, roads, resorts, campgrounds, trails), and do not provide the solitude with which this species seems is associated. Based on the high human use of the area, and the vegetation within and adjacent to the proposed sites is non-habitat, wolverine is not likely to inhabit the proposed site areas, but may use the broader area if transitioning to or from the Cascade Mountains.

There are two records of fisher sightings several miles southwest of Paulina Lake, but reliability of the records is unknown. These historical sightings are a few miles from the nearest proposed site. As with wolverine, habitat conditions for Pacific fisher do not exist within or immediately adjacent to any of the proposed sites, and most of the vegetation interspersed within the sites appears to be too dry and not suitable conditions for this species due to the high component of lodgepole pine and ponderosa pine. Although there are some pockets of montane mixed conifer interspersed between the sites, it would not provide the larger contiguous blocks of habitats preferred by fishers. The most probable habitat or species occurrence may occur within the broader Newberry Crater area or the perimeter of Paulina and East Lake. While there is potential

suitable denning habitat along Paulina Creek, it is unlikely fishers would inhabit this area due to the high presence of recreation. Rather, Paulina Creek would have more potential to be utilized for travel/movement. Similar to wolverine, fishers prefer to inhabit areas with minimal human disturbance. Based on all of these conditions discussed, fishers are given a low probability of occurrence.

The interspersed areas between the proposed sites provides potential or suitable habitat for sensitive species, such as the white-headed woodpecker and Lewis' woodpecker. Paulina Creek, Paulina Lake, and East Lake provide potential habitat for several sensitive species associated with riparian or lake habitats, such as bald eagle, peregrine falcon, bufflehead, harlequin duck, horned grebe, Northern waterthrush, and Crater Lake tightcoil. Several of the proposed monitoring surface sites are north and south of Paulina Creek, while there are two proposed drilling sites approximately ½ mile to the north of Paulina Creek. There are also two surface monitoring sites adjacent to the western flank of Paulina Lake.

The interspersed areas between the proposed sites or adjacent to (i.e. Paulina Creek and East and Paulina Lakes) also provides habitat for Management Indicator Species (MIS) and migratory birds, such as ospreys, great blue heron, a few water fowl species, great gray owl, American marten, olive-sided flycatcher, chipping sparrow, brown creeper, Cooper's hawk, northern goshawk, sharp-shinned hawk, red-tailed hawk, several woodpeckers (i.e. northern flicker, three-toed, black-backed, pileated, and hairy woodpeckers), mule deer and elk (these areas are used by deer and elk mostly during spring, summer, and fall).

Field surveys were conducted by the USFS for the northern goshawk in the Ogden EA project area between July 2nd and July 24th 2009 and again in the 2010 and 2011 breeding seasons in an attempt to locate the presence of a nesting pair (the Ogden wildlife survey area overlaps the entire EGS Project area). Two northern goshawk nest sites with a total of three nests were detected as a result of these surveys. In addition, while there are no known active eagle or osprey nests, there is a historical osprey nest located within the riparian area along Paulina creek.

The approximate distance from any known nest site, and the historical Osprey nest site, to the nearest proposed EGS EA site is provided below:

- Osprey Nest (S 31, Paulina Creek): NN17 = 0.6 miles
- Goshawk Nest T22S, R11E, Sec. 10: NM11 = 3.2 miles
- Goshawk Nest T22S, R11E, Sec. 25: TG17 = 1.2 miles

In addition to utilizing the Ogden EA wildlife surveys, the Forest Service conducted surveys specifically for the Temperature Gradient sites (in Figure 2) in the 2010 and 2011 breeding seasons, but no raptors were detected. In the 2011 breeding season, the Forest Service also conducted goshawk surveys for all the surface stations and the three new borehole MSA stations (NN 17, NN 24, and NN19), but no raptors or raptor nests of any kind were detected.

The detailed findings from these reports, including the surveys are on file at the BLM Prineville District Office.

3.5 Scenic Resources

Introduction

A scenic resource analysis was completed by Robert Scott Environmental Services to identify and describe the effects of the proposed project on scenic values within the Project area. The analysis was conducted in compliance with the Forest Service Visual Quality System (VQS) and in conjunction with federal guidelines established by the Forest Service Scenery Management System (SMS). The analysis evaluates existing viewsheds affected by activities within the sites proposed in the Proposed Action and Alternative B. This study area was defined by considering the relationship of the proposed EGS Project to the surrounding topographic and vegetative patterns, relative to key viewer locations. The analysis is documented in a technical report, "Scenic Resources Inventory and Assessment Newberry Volcano EGS Demonstration Project, Deschutes County, Oregon", which is on file and publicly available upon request at the BLM Prineville Office.

The proposed EGS Project must be consistent with the current Forest Plan for the Deschutes National Forest. For visual resource descriptions and guidance, the Forest Plan establishes Visual Quality Standards using methodology from the Visual Quality System (VQS). In 1996 a new methodology called the Scenery Management System (SMS) was incorporated into Forest Service directives[18]. The Scenery Management System provides additional social components for use in the evaluation of alterations to scenery that are not present in the Visual Quality System. In order to determine consistency with the Forest Plan visual quality standards, the EGS EA provides a cross-walk of the aspects of the Scenery Management system that equates to the Visual Quality standards in the Forest Plan.

The Deschutes National Forest Land and Resource Management Plan establishes Visual Quality Objectives (VQO) to determine how the visual resources of an area are managed. Each Visual Quality Objective describes a different degree of modification allowed in the landscape and is represented over a continuum of four classes of VQOs from very high to very low standards. The four classes of VQOs are:

1. Preservation-P. Allows ecological changes only and applies to wilderness and primitive areas. There are none of these in the study area.
2. Retention-R. Activities may only repeat form, line, color, and texture which are frequently found in the characteristic landscape. Changes in their qualities of size,

[18] Landscape Esthetics: A Handbook for Scenery Management. Forest Service Handbook 701. USDA Forest Service 1996.

amount, pattern, etc., should not be visually evident. There are none of these in the study area.

3. Partial Retention-PR. Activities remain visually subordinate to the characteristic landscape. Activities may repeat form, line, color, or texture common to the characteristic landscape, but changes remain visually subordinate to the strength of the characteristic landscape. Existing well pad NWG 55-29 and Borehole NN19 are within this classification.
4. Modification-M. Activities may visually dominate the existing characteristic landscape. However, activities which alter vegetation and landform must borrow from established form, line, color, or texture and at such a scale that its visual characteristics are similar to those of existing occurrences within the surrounding area of character type. This class applies to all sites within the General Forest MA, and includes Boreholes NN17 and NN24.

In the Scenery Management System, the FS combines the component inventories into Scenic Integrity Levels, which are objectives by which visual resources of an area are managed by the FS. Scenic Integrity Levels are determined by synthesizing in matrix form the inventories of scenic attractiveness, landscape visibility and visual concern, and seen areas and distance zones. A Scenery Management System rating system is applied to distinguish scenic integrity, which indicates the degree of intactness and wholeness of the landscape character. Human alterations can sometimes raise or maintain integrity. More often it is lowered depending on the degree of deviation from the character valued for its aesthetic appeal.

Scenic integrity is a continuum ranging over five levels of integrity from very high to very low. Corresponding levels of existing scenic conditions and visual quality levels from the original Visual Management System are shown in parentheses.

- **Very High Scenic Integrity – Unaltered (Preservation)**

  Refers to landscapes where the valued landscape character is intact with only minute if any deviations. The existing landscape character and sense of place is expressed at the highest possible level.

- **High Scenic Integrity – Appears Unaltered (Retention)**

  Refers to landscapes where the valued landscape character appears intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident.

- **Moderate Scenic Integrity – Slightly Altered (Partial Retention)**

  Refers to landscapes where the valued landscape character appears slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.

- **Low Scenic Integrity – Moderately Altered (Modification)**

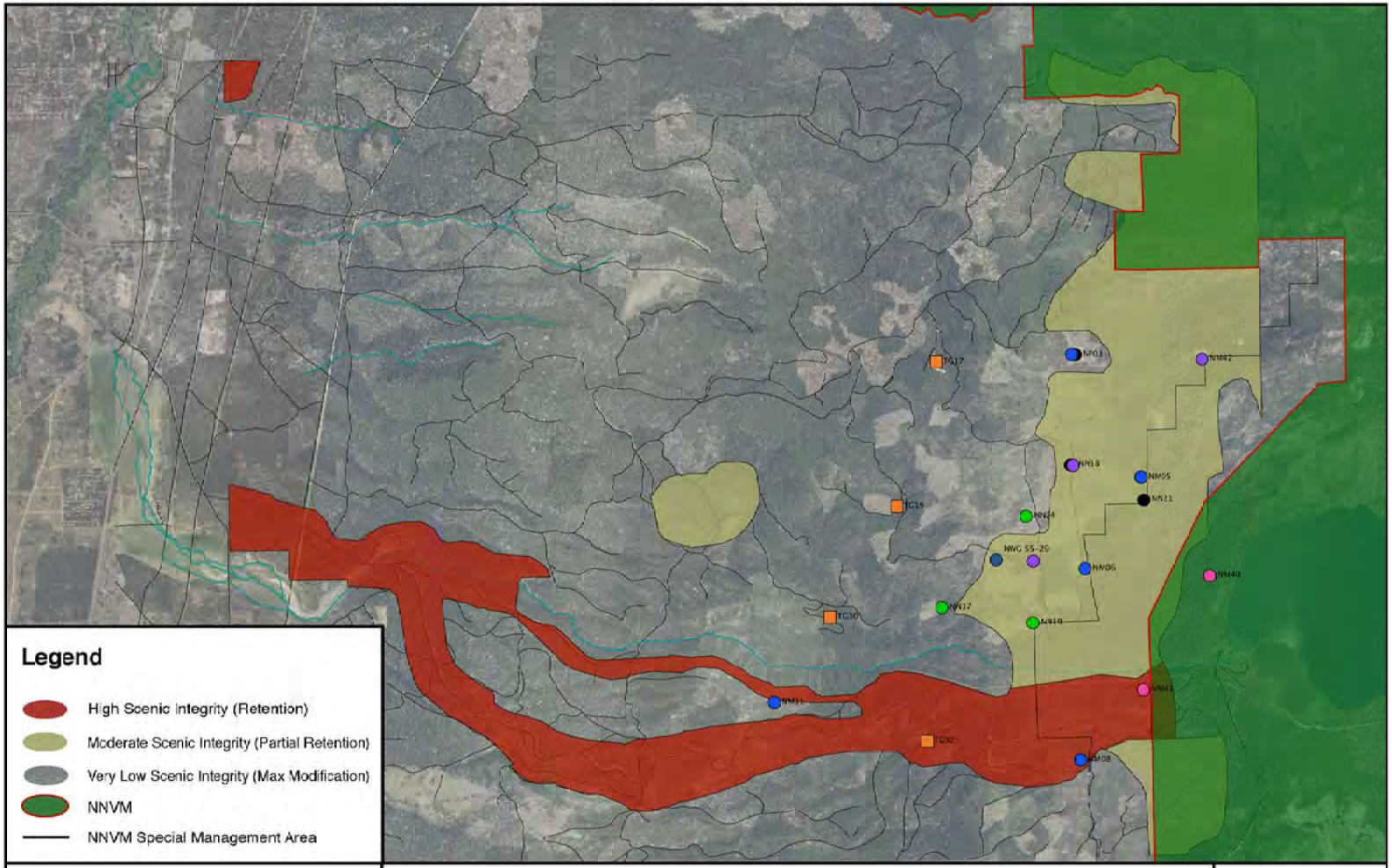
  Refers to landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed

but they borrow valued attributes such as size, shape, edge effect and pattern of natural openings, vegetative type changes or architectural styles outside the landscape being viewed. They should not only appear as valued character outside the landscape being viewed but compatible or complimentary to the character within.

- **Very Low Scenic Integrity – Heavily Altered (Maximum Modification)**

  Refers to landscapes where the valued landscape character appears heavily altered. Deviations may strongly dominate the valued landscape character. They may borrow from valued attributes such as size, shape, edge effect and pattern of natural openings, vegetative type changes or architectural styles within or outside the landscape being viewed. However deviations must be shaped and blended with the natural terrain (landforms) so that elements such as unnatural edges, roads, landings, and structures do not dominate the composition.

The general Newberry area is known for its volcanic features, as evident from the numerous landforms including lava flows, volcanic cones, and lava buttes rising from the surface of the surrounding area. The fairly homogenous and extensive vegetation patterns present are dominated by mature stands of lodgepole pine. These homogenous landscapes have been broken into visual mosaics with blocks of even-aged younger stands of lodgepole represented across the landscape. These mosaics result from a combination of natural regeneration after landscape-scale mountain pine beetle mortality, concentrated blocks of regenerated stands following past even-aged harvests, and large-scale wildfires. Active forest management, which primarily focuses on thinning to reduce the density of the overall homogenous vegetation patterns, is ongoing throughout the study area.


Legend
High Scenic Integrity (Retention)
Moderate Scenic Integrity (Partial Retention)
Very Low Scenic Integrity (Max Modification)
NNVM
NNVM Special Management Area
PLS Environmental
Scenic Integrity Levels
Figure V-1

Summary of Existing Conditions for Scenic Resources

As shown in Figure V-1 and Table 6, for sites within MA-9 (Scenic Views), the site of primary activity, NWG 55-29, and one new borehole station (NN19) are located within the Moderate Scenic Integrity Level – Slightly Altered (Partial Retention VQO). The two other new borehole MSA stations are located in the Low Scenic Integrity Level – Moderately Altered (Modification VQO). Table 6 summarizes the existing visual conditions at NWG 55-29 and the three new MSA boreholes within the Scenic Views Management Area.

Table 6: Summary Of Existing Visual Conditions

Proposed Project Facility	SMS[1]	VAC[2]
Well Pad 55-29	Moderate	Moderate to High
Borehole NN17	Low	High
Borehole NN24	Low	High
Borehole NN19	Moderate	High

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

[1]SMS – Scenic Integrity Level: Moderate Scenic Integrity (Partial Retention), Low Scenic Integrity (Modification)

[2]VAC – Visual Absorption Capability

3.6 Water Resources

The following description of the hydrologic system in the Project area is primarily based on a recent report written by Kleinfelder (2011)[19] to provide an independent review of hydrology information for the Project. This independent hydrologist report is included as Appendix B. Information from the 1994 Newberry Geothermal Pilot Project EIS is also used to provide context for hydrologic resources in the area.

There are several hydrologic features that were considered and evaluated for potential effects resulting from proposed EGS activity:

- East Lake and Paulina Lake in the Newberry caldera;
- Thermal springs around the lakes;
- Regional and local groundwater systems;
- Surface outflow from Paulina Lake into Paulina Creek; and
- Surface outflow from the Little Deschutes River.

[19] Figures and references noted in this section may be found in the report in Appendix B.

The hydrologic system and water resources at Newberry are part of the upper Deschutes Basin which is within the larger Deschutes River drainage basin of central Oregon. The system represents a dynamic equilibrium between recharge, surface and groundwater outflows, consumptive use, and evapotranspiration.

Caldera Lakes

It is well-documented that East and Paulina Lakes recharge almost exclusively by precipitation and infiltration, with approximately 35 inches of rain and snow falling into the caldera annually. East Lake does not have a surface water outlet, while Paulina Lake discharges through a dam and outlet structure into Paulina Creek and is used for irrigation purposes. The level of Paulina Lake and outflow volume to Paulina Creek have been controlled and managed at the dam since the early 1900s. Lake levels naturally fluctuate seasonally dependent upon precipitation; however, the elevation of East Lake is generally 40 to 50 feet higher than Paulina Lake. The hydraulic gradient from East Lake toward Paulina Lake and the relative stability of Paulina Lake and nearby groundwater levels relative to East Lake levels, indicate there is appreciable groundwater flow from East Lake into Paulina Lake.

The groundwater system within the caldera appears to be structurally-controlled by faulting and a series of ring-fractures around the caldera. These faults and ring-fracture structures create groundwater flow boundaries that impede the vertical and/or horizontal flow of groundwater out of the caldera, although some groundwater flow from the caldera to regional and local aquifer systems does occur.

Thermal Springs

There are two distinct components of the hydrothermal system at Newberry Caldera: a shallow hydrothermal system consisting of thermal springs near the surface and a deep geothermal system consisting of higher temperatures and depths greater than 1,300 feet below ground surface.

Thermal springs and diffuse seeps can be found along the northeast shore of Paulina Lake and the southeast shore of East Lake. The springs are considered to be fumaroles (gas vents) covered by the lakes and are not the result of deep geothermal fluid, nor are they connected to a deep geothermal system outside the caldera. They have been created by the recirculation of heated water and/or by mixing with steam that migrates up through fractures from a deeper system inside the ring-fractures and within the caldera. The recharge volume from thermal springs and diffuse flows to the caldera lakes has not been quantified, however it has been described as many small diffuse flows and is relatively small compared to recharge from precipitation (Kleinfelder, p 3).

Groundwater Systems

Groundwater underlying the west flank of Newberry volcano and the La Pine sub-basin is divided into two systems (regional and local) based upon geology, aerial extent, and flow characteristics. The prolific regional aquifer is of wide aerial extent and hosted in basaltic lavas, volcaniclastic rocks, and sedimentary units of the Deschutes Formation that overlie low permeability basement rocks of the Clarno and John Day Formations. The depth to the top of the regional aquifer varies based upon elevation; however, it

generally ranges from 100 to over 500 feet below the ground surface (bgs). The "local" aquifer is of lesser aerial extent and made up of unconsolidated, glaciofluvial sediments under water table (unconfined) conditions. These materials blanket most of the La Pine sub-basin and were deposited as outwash from glaciers emanating from the High Cascade Range to the west. The local aquifer is comprised of well-graded sand and gravel with minor interbeds of low permeability silt and clay that overlie clay-rich marsh and lacustrine deposits associated with the damming of the ancestral Deschutes River. Most domestic wells in the La Pine sub-basin are drilled into the "local" aquifer and depths are generally less than 50 feet bgs. Water levels from wells installed at various depths within the local system generally show similar water levels (5 to 15 feet bgs), which suggests there is no significant vertical movement of water in the local aquifer (Century West Engineering, 1982).

Based on loss zones encountered while drilling, isothermal temperature profiles, and alteration described in mud logs, the shallow, mostly unconfined aquifer intersected by the water wells on pads S-16 and S-29 (well numbers DESC 58649 and DESC 58395, respectively) only extends to depths of about 300 m (984 ft) across the project area, with some spatial variability (Dames and Moore, 1994). Below this depth, decreasing permeability caused by increased clay content forms a basal aquiclude, or the bottom of the aquifer. The top of the aquifer likely fluctuates several meters or more depending on seasonal precipitation. The depth to groundwater in the S-29 water well and S-16 water well were recently measured at 324 feet below ground surface (bgs) and 678 feet bgs respectively.[20]

The groundwater system is recharged by infiltration of precipitation (rainfall and snowmelt), and to a less extent by canal leakage, infiltration of applied irrigation water, and stream loss. Precipitation is the primary means for recharge, and there is a strong correlation between recharge and elevation. Recharge from precipitation ranges from less than 1 inch/year in the lower elevations where precipitation is less than 12 inches, to more than 130 inches in the High Cascade Range to the west where precipitation exceeds 200 inches. The mean recharge to the upper Deschutes Basin between 1962 and 1997 has been estimated at 11.4 inches/year, which is equivalent to 896 billion gallons, or 2,750,000 acre-feet/year (Gannett and others, 2001). About 84 percent of recharge from precipitation infiltration occurs between November and April (Gannett and others, 2001). Recharge to the groundwater system from the west flank of Newberry volcano may approach 224,000 acre-feet/year (Dames and Moore, 1994). The Fort Rock Basin to the southeast also contributes approximately 36,200 acre-feet/year to the upper Deschutes Basin (Gannett and others, 2001).

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[20] Aquifer Pumping Test Report Pad S-29 Water Well Newberry Volcano EGS Demonstration Project, Wallace Group, 2011.

Groundwater flows eastward from the High Cascade Range and west-northwest from Newberry volcano toward the La Pine sub-basin where it enters the regional and local aquifers. From the La Pine sub-basin, groundwater flow is generally to the north within basalt bedrock and overlying volcanic and sedimentary deposits of the Deschutes Formation. The Clarno and John Day Formations underlie the regional (Deschutes Formation) aquifer and include low permeability stratigraphic units that inhibit the horizontal and vertical flow of regional groundwater (King, 1991). The shallow, local aquifer extends north approximately 18 miles to the Benham Falls area where the ancestral Deschutes River was dammed by Newberry lava flows erupted from a cinder cone in the northwest rift zone (Lava Butte), approximately 7,100 years ago. There is an abrupt topographic gradient north of Benham Falls at the contact between Newberry lavas and those of the High Cascade Range with source areas to the west.

Correspondingly, the Deschutes River gradient increases from approximately 2.6 feet per mile (ft./mi.) in the La Pine sub-basin to 50 ft./mi. between Benham Falls and Bend. The slope of the water table also increases north of Benham Falls. The depth to water near the river at Benham Falls ranges from approximately 5 to 25 feet bgs. Approximately 8 miles to the north beneath Bend, the depth to the regional aquifer increases to over 300 feet bgs (Sherrod and others, 2002).

The northward-increasing depth to groundwater has implications for the interaction of the groundwater system and surface water. Within the La Pine sub-basin south of Sunriver, the Deschutes River system experiences slight gains due to groundwater discharge and significant gains from several major spring complexes. North of Sunriver, the Deschutes system begins to lose water as groundwater levels drop far below stream levels. Between Sunriver and Bend, the Deschutes River loses an estimated 113 cfs as it flows through permeable volcanics of Lava Butte and the north rift zone (Gannett and others, 2001).

Paulina Creek

Paulina Creek begins at the southwest shore of Paulina Lake at an elevation of 6,330 feet and flows west over 13 miles to the confluence with the Little Deschutes River at an elevation of 4,180 feet. The flow of Paulina Creek is controlled by a concrete spillway that has been in-place since the early 1900s. Paulina Creek gauge records indicate seasonal flows between March and June of 15 to 25 cfs, when snowmelt is peaking and the lake reaches the spillway elevation. Outflows of 10 to 15 cfs are generally sustained through the irrigation season (April through October). There are six senior water rights for Paulina Lake and Paulina Creek irrigation water dating back to 1911 and 1918. These senior water rights total approximately 8 cfs.

Above the Paulina-East Lake Road (also known as Highway 21 and Forest Road 21) crossing at river mile (RM) 5.2 (Figure 17), the stream loses approximately 0.75 cfs/mile to groundwater (Morgan and others, 1997). Below RM 5.2 Paulina Creek does not appear to lose flow to groundwater and may receive some minor recharge as the stream intersects groundwater levels of the near-surface, local aquifer.

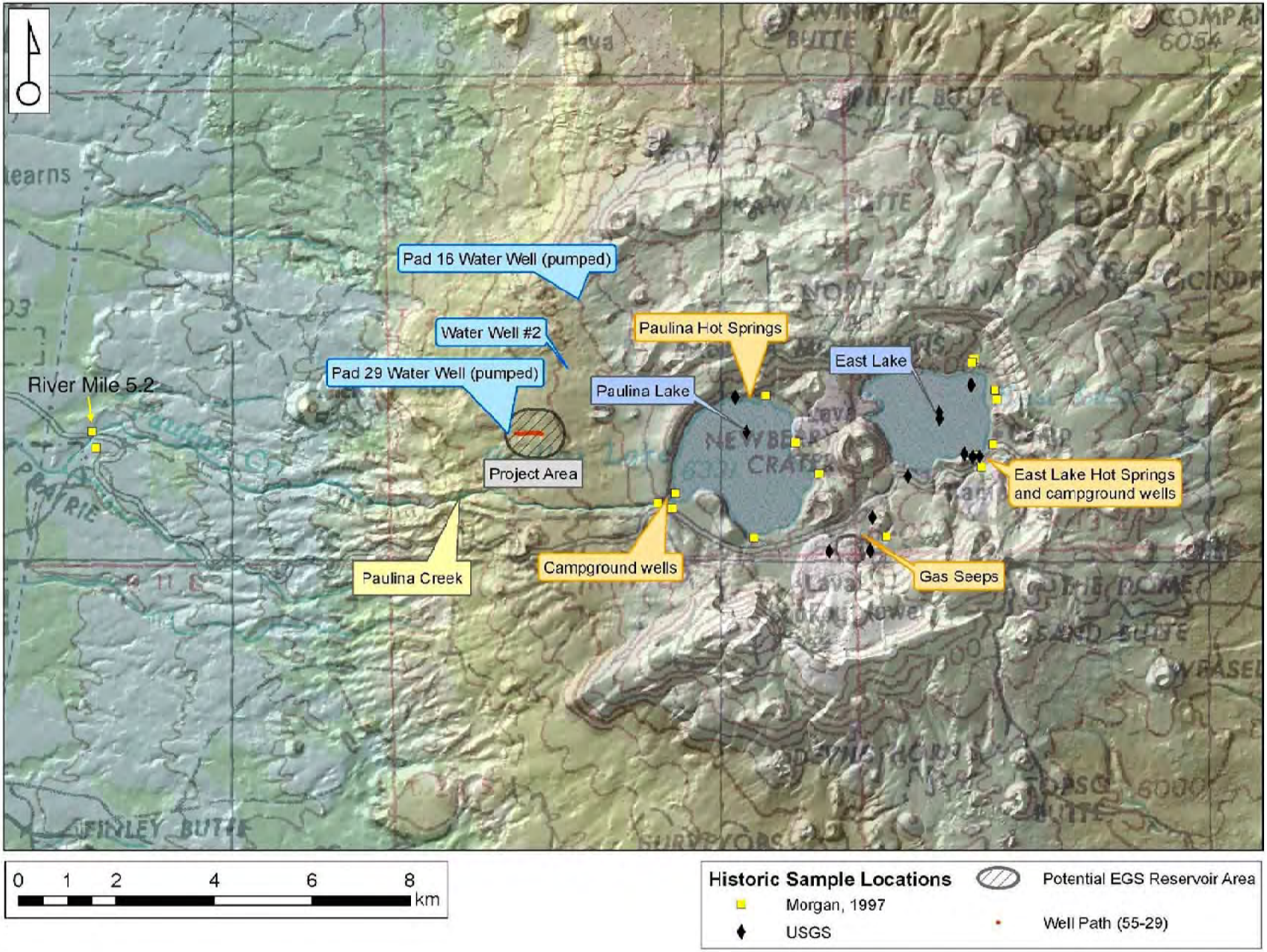


Figure 17: Water Point Location Map

Little Deschutes River

Paulina Creek joins the Little Deschutes River near Little Deschutes RM15. In this portion of the La Pine sub-basin, the water table elevation is near land surface. Stream gains and losses along most of the Little Deschutes River are small and related to local changes in stream bed morphology. There is relatively little net exchange between groundwater and surface water in the Little Deschutes River between RM15 and its confluence with the Deschutes River.

3.7 Geology and Natural Seismicity

During early planning, and as required by DOE, the Proponents commissioned an independent evaluation of induced seismicity/seismic hazards and risk for the Project. This study, prepared by the Seismic Hazards Group at URS Corporation in November 2010, evaluated the baseline seismic hazards in the Project area, estimated the potential increase in seismicity rate and the maximum magnitude of an earthquake induced by hydroshearing below NWG 55-29, and evaluated the increased seismic risk imposed by the hydroshearing activity. The following description of the geology and background seismicity in the Project area is based on this report. The report, and a follow up study to that report, is included in Appendix F and G of the ISMP, which is attached as Appendix A to this document[21].

Seismotectonic Setting

An understanding of the seismotectonic setting of a site provides the framework in which the earthquake potential of geologic structures in a region can be identified and characterized. The following is a brief summary of the seismotectonic setting of Newberry Volcano.

From a global perspective, central Oregon is dominantly influenced by the underthrusting and subduction of the Juan de Fuca plate beneath the North American continent along the Cascadia trench. Oblique subduction of the Juan de Fuca plate has created a north-south trending volcanic range that extends from northern California to southern British Columbia. In central Oregon, the range is dominated by late Pleistocene stratovolcanoes including Mt. Jefferson and the Three Sisters.

Patterns of seismicity, volcanism, and crustal structure differentiate the range into blocks, with the boundary of the Oregon block extending from the Oregon-Washington border to the Klamath Mountains, which mark the northern boundary of the Sierra Nevada block. The volcanic arc in this Oregon block is characterized by lower rates of seismicity, particularly in comparison to the Sierra Nevada which has generally higher rates of seismicity along its eastern edge. Central Oregon is a complex transitional region, as the

[21] Figures and references noted in this section refer to the reports that may be found in Appendix F and G of the ISMP attached as Appendix A to this document.

region is influenced in part by the northernmost extent of the Basin and Range extensional tectonics and also by volcanic processes that characterize the High Cascade region.

Regional active faulting in Oregon is largely concentrated along four north-trending fault zones broadly distributed in central and eastern Oregon. Despite the lack of large magnitude earthquakes in the historical record in Oregon, it is likely that active fault zones in Oregon serve to kinematically connect seismic activity in northeastern California and northwestern Nevada to seismically active fault zones in southern and central Washington.

The regional tectonics near Newberry Volcano is unique because of its location east of the Cascade Range. Extensional movements in the Newberry region are accommodated by slip along three principal fault zones that show Quaternary and Holocene displacements and probably intersect or merge beneath the caldera and shield, including the Northwest Rift zone, the Southeast Newberry fault zone, and the Southwest Newberry fault zone. On the northeast side of Newberry Volcano, the Brothers fault (Figure 9 – appendix 'F' of the ISMP) offsets Miocene and Pliocene volcanics, yet does not appear to offset Quaternary lava flows. The Brothers zone is nevertheless included in the hazard analysis.

Historical Seismicity

Prior to about 1961, earthquake locations and size estimates are mostly based on pre-instrumental records and felt reports. Earthquake data were gathered from newspaper accounts, which began with the establishment of settlements in the region.

Pre-Instrumental Seismicity

No earthquakes greater than magnitude (M) 5.0 occurred within 100 km (62 miles) of Newberry Volcano between 1891 and 1961 (Figure 18). The closest large event, 165 km (103 miles) southwest of Newberry Volcano, was the M 6.0 Klamath Falls earthquake that occurred on October 21, 1993. Several moderate-sized events have occurred since 1891 and include three M 4.3 or Modified Mercalli intensity (MM) V earthquakes in 1906, 1920 and 1921 none of which were felt at the site (Figure 18). The largest and most significant earthquake in eastern Oregon, known as the Milton-Freewater or Stateline earthquake, occurred on July 15, 1936. Based on the isoseismal map and an empirical relationship between magnitude and total felt area, the event was estimated to be an M 6.4.

Instrumental Seismicity

There have only been six M 3.0 or greater earthquakes within 100 km (62 miles) of the Newberry Volcano since 1980 (Figure 18). Of these events, four were in 1999 consisting of a minor swarm of earthquakes during April and May. The largest event in the swarm was an M 4.3 earthquake on April 28, 1999, located about 98 km (61 miles) southeast of the Newberry Volcano (Figure 18), and was felt at Christmas Valley and Paisley, Oregon. The closest M 3.0 and larger earthquake to the Project site was an event estimated at M 3.0 in 1943 about 35 km (22 miles) north of the site (Figure 19).

Based on the instrumental record, no earthquakes have been located within 10 km (6 miles) of well NWG 55-29 or Newberry Volcano (Figure 19).

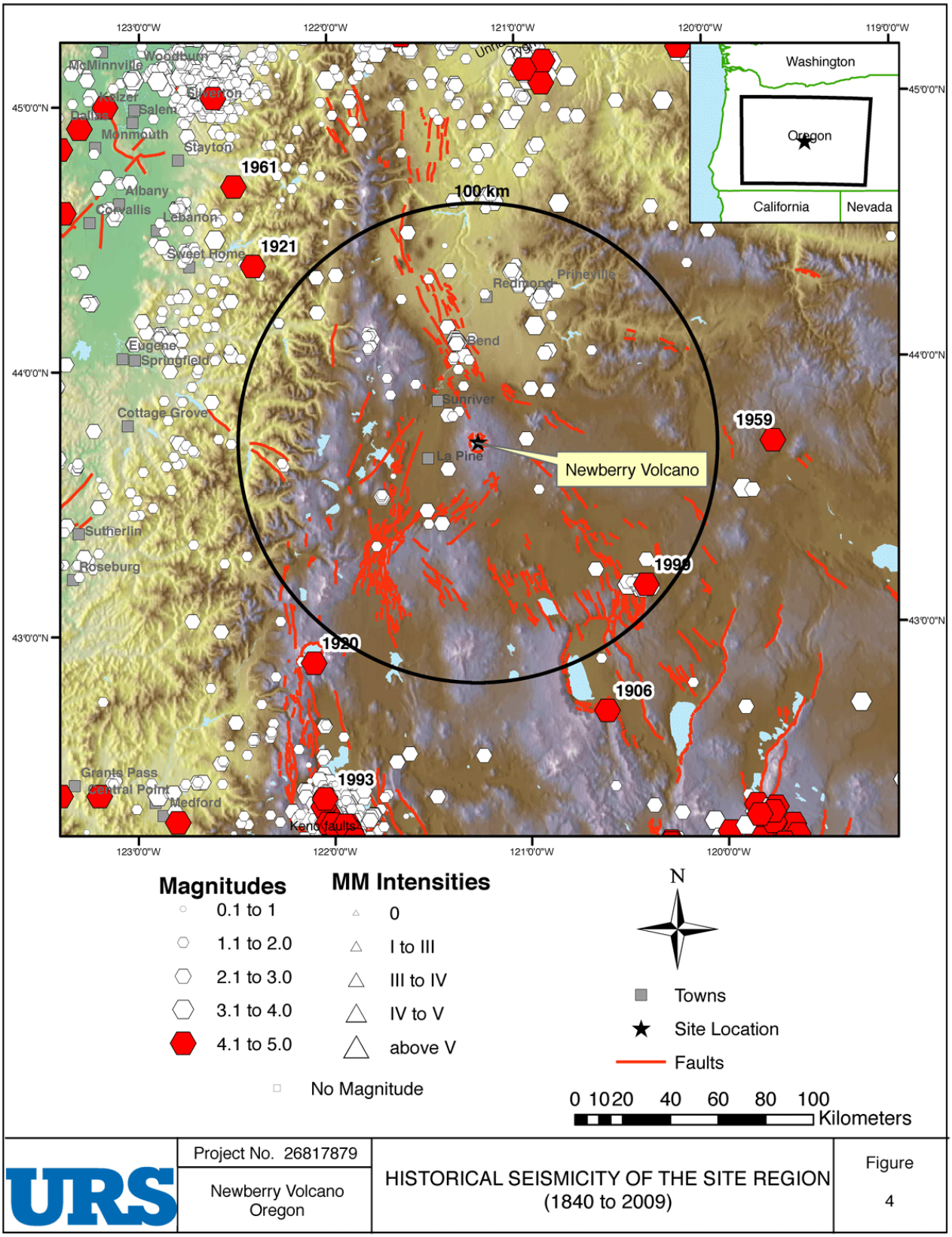


Figure 18: Historical Seismicity of the Site Region

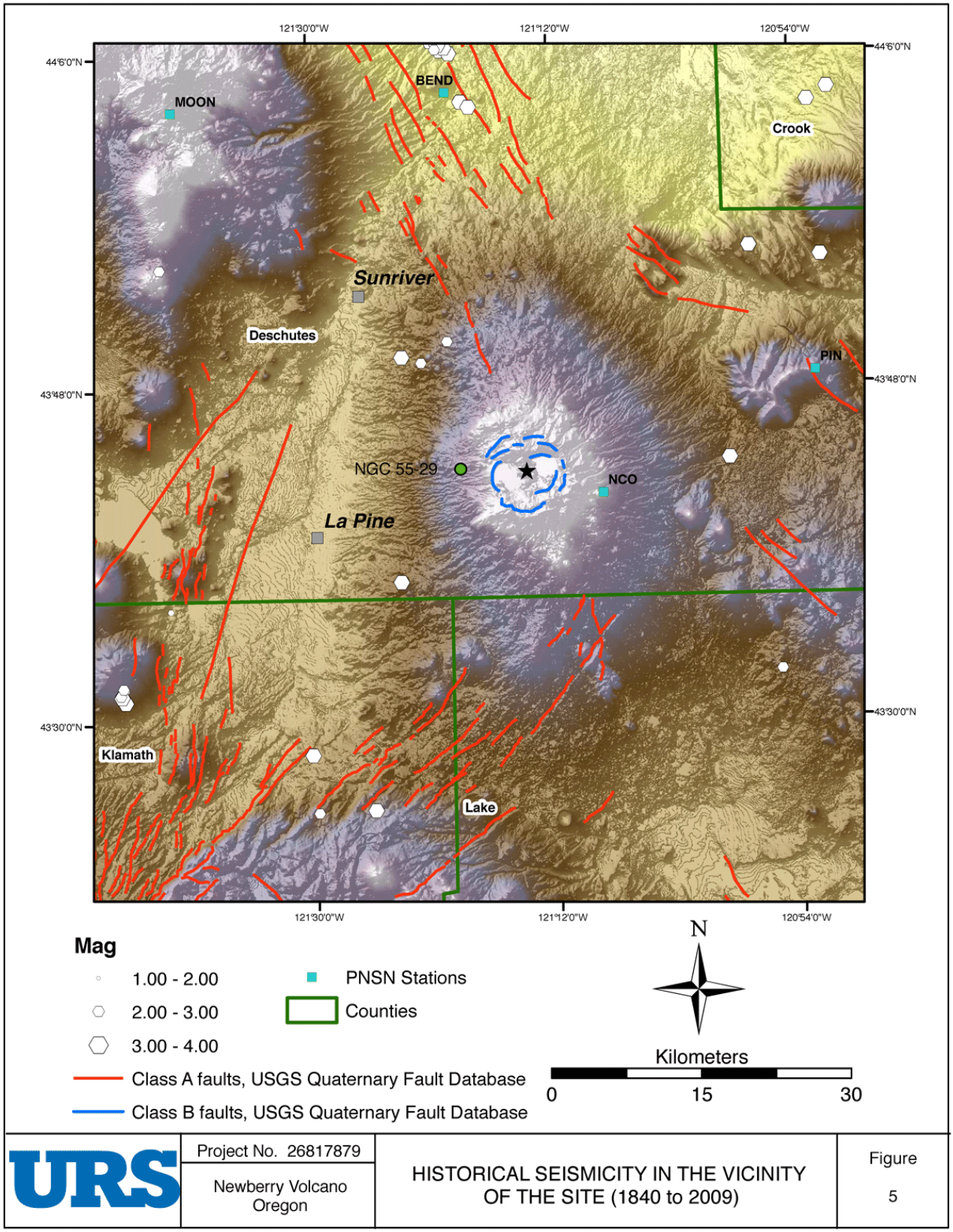


Figure 19: Historical Seismicity in the Vicinity of the Site

CHAPTER 4. ENVIRONMENTAL EFFECTS

4.1 INTRODUCTION

This chapter describes the expected environmental effects of implementing Alternative A, the proposed action; Alternative B, the proposed action with closed pressure vessel and air cooled condensers; and Alternative C, the no action alternative, and provides the scientific and analytic basis for their comparison. All known environmental effects including direct, indirect, and cumulative effects are disclosed and mitigation measures to reduce any potential adverse effects are described within this chapter.

This chapter contains summaries or portions of resource reports that can be found in the appendix and/or in the Administrative record.

The analysis presented here considers direct, indirect and cumulative effects. Direct environmental effects are those occurring at the same time and place as the initial cause or action. Indirect effects are those that are caused by or will result from the proposed action and are later in time or farther removed in distance, but are still reasonably certain to occur. Finally, cumulative effects result from collective past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such actions.

4.2 PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS IN THE PROJECT AREA

There have been a considerable number of past National Forest projects and activities in and around the 32,000 acre geothermal lease area in which the EGS Demonstration Project is proposed.

The following table (Table 7) lists the groups of actions that have contributed to the existing conditions within the project area. Table 8 lists ongoing or reasonably foreseeable future actions in the project area. The effects analysis throughout this chapter considers these past actions as contributing to the current condition.

Table 7: Past Actions and Events the Contribute to the Current Conditions in the Project Area and Cumulative Effects Area

Past Actions	Timing	Description	Residual Effects
Road Access			
Forest System Roads All within project area	1920s to Present	Road system developed 175.1 miles of open road; 6.1 miles of closed road (maintenance level 1).	Current transportation system road density is 4.22 miles per square mile; access, habitat fragmentation
Wildfire			
All within project area	1918	Paulina Prairie wildfire 2,827 acres	Contributed to current tree size/structure and species composition. The McKay fire is in the center of the project area and comprised primarily of shrubs and planted regeneration. PCT and mowing are planned in the Ogden project.
	1918	Paulina Creek wildfire 169 acres	
	1994	Ogden wildfire 13 acres	
	1998	McKay wildfire 1,150 acres	
	1999	Black Bark wildfire 79 acres	
	2000	Newberry 2 wildfire 548 acres	
Vegetation Management / Fuels Reduction Projects			
Industrial Timber Operations	1920s-1930s	Extensive railroad logging across project area, primarily clearcutting.	Extensive areas of single-story ponderosa pine. Lodgepole pine in extensive plantations and has expanded its stocking substantially – particularly within Ogden to the West and outside Ogden to the South.
Thinning and other harvest	1970s 1980s 1990s	Thinning, regeneration harvest, and other management has occurred throughout the planning area since it was added to the Deschutes NF.	Past harvest has contributed to the current vegetative structure in the area and is reflected in the current condition assessment for forested vegetation and fuels.

Past Actions	Timing	Description	Residual Effects
Lava Cast Project	DN signed 2007 Alternative 3	Commercial thinning and fuels reduction analyzed for 9,515 acres north of project area. Harvest complete. Commercial and small tree thinning. Fuels Treatments ongoing. Prescribed burning including pile and underburning. Two of the three sales (Bon and Dice Timber Sales) have completed fuels treatments	More open stands of ponderosa pine with substantial reduction of stand density. Basal area at lower management zone. Stand density reduction with 1) reduced risk of tree mortality as a result of beetle attack and 2) reduced risk of stand replacement wildfire.
Crossings	Decision Memo signed 7/2006.	Fuels reduction within the LaPine Wildland Urban Interface (WUI) Community Wildfire Protection Plan (CWPP) – the western edge of project area. 1,000 acres of ladder fuel reduction, low thinning, hand piling and mowing. All project work completed in 2010.	Fuel treatments in this area will be effective for approximately 7-10 years. Surface fire after this time would be fast moving with some torching of trees.
Range			
Sugarpine Allotment Sand Flat Allotment	SP - Closed 2007 SF - Vacant	Two range allotments have had activity within the project area. The Sugarpine Allotment has been closed. The Sand Flat Allotment is vacant.	All Sugarpine Allotment fences have been removed; risk to wildlife and humans reduced. Two cattle guards have been removed and others are planned for removal, reducing maintenance costs.
Geothermal Exploration and Other Misc.			
Newberry Geothermal Pilot Project FEIS/ROD	ROD signed 6/30/1994	Authorized exploration and development on CalEnergy leases (currently owned by Ormat) Three drill pads were constructed and two pads were partially constructed for surface disturbance of 31 acres. One water well, three production wells, and two temperature gradient exploration wells were drilled.	Resource not developed; Sites undergoing reclamation. Two pads have been re-contoured and prepped for natural regeneration; three pads anticipated for re-contouring and prepped for natural regeneration in 2011. Three of the wells have been plugged and abandoned. One well and the water well have not been plugged or abandoned.

Past Actions	Timing	Description	Residual Effects
USGS Permanent Volcanic Monitoring Stations	Categorical Exclusion completed Aug. 2011; stations installed.	Monitoring stations to track seismic activity. Stations located in areas not obvious to the general public. One station to be located at NNVM visitor center or Newberry Crater.	Structures minimize detraction of the surrounding area. Ground disturbing area does not exceed 100-200 feet.

Table 8: Ongoing or Reasonably Foreseeable Future Actions, in the Project Area and Lower Little Deschutes Watershed that may Contribute to Cumulative Effects

Project Name / Activity	Status/Timing	Description	Predicted or Ongoing Effects
Geothermal Exploration			
Newberry Geothermal Exploration Project	Decision Record signed by BLM in 2007	The improvement of required Forest Service access roads; construction of three well pad sites, including drilling pads and a reserve pit for the storage of waste drilling mud and fluid; the drilling (and re-drilling, as may be necessary) of up to nine geothermal resource exploration wells; testing of each drilled well; and the continued monitoring of well pressure and other data in each well.	Three well pads, each 5 acres in size. All three currently in exploration; one well pad has geothermal exploration ongoing and is being considered for use in the Newberry Volcano EGS Demonstration Project. Continued access needed. Existence of temporary road. Potential short-term disruption of recreation or management activities on access roads for road maintenance and equipment moving.
Drilling, Testing, and Monitoring of up to 12 Temperature Gradient / Passive Seismic Geothermal Exploratory Wells	Decision Record signed by BLM in April 2010;	Drill up to 12 temperature gradient / passive seismic monitoring wells, each to depths of approximately 2,500 to 3,500 feet. Relatively shallow wells; small diameter (4.5" or less).	Small clearings in vegetation totaling about 2.5 acres; Work to be completed summer 2011; wells maintained and monitored through 2012. See road access discussion above.
Micro-Seismic Testing	Forest Service CE signed Jan. 2010 for Special Use Permit Testing ongoing	12 stations each 2 feet wide by 1 to 4 feet in depth; data collection at each site.	Currently collecting data. Stations are to be removed 4 to 10 months following installation and will become holes instead of surface sites. See road access discussion above.

Project Name / Activity	Status/Timing	Description	Predicted or Ongoing Effects
Forest Service Consent to Lease	Planning EA expected to be signed 2011	Forest Service assessing which parcels to consent to leasing for geothermal exploration and identifying mitigations measures if developed. All parcels outside NNVM.	No ground-disturbing actions will be authorized. Programmatic decision. Future development would undergo further NEPA.
Ogden Vegetation Management Project	FS DEIS in progress. Decision expected Jan. 2012	Proposal includes commercial and precommercial thinning, shrub mowing, and prescribed burning across approx. 14,600 acres of the 26,500-acre project area to reduce tree densities, encourage late and old structure pine development, break up fuel continuity; 2 plan amendments minimize surface disturbance.	The goal of the project is to reduce forest density and fuels in the project area. Vegetation clearing and prescribed burns would occur throughout the project area.
Ormat Temperature Gradient Well Proposal	BLM and FS NEPA document expected to be completed in 2012.	A special use authorization is proposed to be issued to Ormat Technologies, Inc. to drill up to seven temperature gradient wells for the purpose of geothermal resource exploration. Well sites (about 100 X 100 feet) have experienced previous disturbance and are mostly clear of vegetation, and do not require any site grading or conditioning to perform drilling operations.	Project effects are within the Upper Paulina subwatershed wildlife cumulative effects analysis area.
Recreation			
Lava Rock OHV Trail Project	Planning	41.9 miles of motorized trail to be designated within project area; 101.5 miles of motorized trail to be designated within the Little Lower Deschutes watershed. 58.5 miles of level 2 FS roads would become level 1 roads.	Potential increase of user-created trails in areas that are thinned and/or underburned, with potential for increased motorized use into RHCA. Less overall cross-country use throughout project area because of trail designation and travel mgmt. restrictions.

Project Name / Activity	Status/Timing	Description	Predicted or Ongoing Effects
Developed Recreation	Seasonal, Ongoing	McKay Campground Ogden Group Camp Paulina Plunge	Recreational use by public, primarily during Spring through Fall. Soil compaction of immediate areas. When campgrounds are full, use is spread to other areas, particularly on user created roads, often into riparian habitat.
Dispersed Recreation	Seasonal, Ongoing	Peter Skene Ogden trail; 7.08 miles of non-motorized trails; OHV use occurring in area; User created dispersed campsites, including along Paulina Creek	Areas possibly more accessible as result of thinning: 1) user created trails; 2) campsites etc. This could result in disturbance to wildlife, soils, RHCA, other resources.
	Seasonal, Ongoing – Winter use only	6 Mile Sno Park 10 Mile Sno Park 29.39 miles of winter trail 3.13 of Nordic Trails 26.26 miles of snowmobile trail grooming	None. Sno parks adjacent to Forest Road 21. Snowmobile trails over snow do not add to soil compaction.
Roads			
Road Closures	Planning	58.5 miles of maintenance level 2 roads would become level 1 roads under the Lava Rock OHV Project EIS, currently in the planning stages.	Reduction in road density. Reduces habitat fragmentation.
Deschutes-Ochoco Travel Management Project	Draft EIS; Implementation expected in 2011	Implementation of the Travel Rule.	Motorized travel in Central Oregon would be restricted to designated roads and trails only. Access to dispersed camping would have special provisions to limit access to sensitive areas.

4.3 Alternative A–Proposed Action: Direct, Indirect and Cumulative Effects

This section analyzes the direct, indirect and cumulative effects for Alternative A, the proposed action, for each resource that was identified during scoping, as related to a key issue. Details of this alternative are discussed above in Chapter 2.3.

Wildlife Key Issue

Preparing and clearing the vegetation for the three borehole MSA stations have the potential to remove habitat on these sites for some species. Drilling activities, testing and stimulation activities, and an increase in human disturbance also have the potential to disturb nesting sites up to ¼ mile during the breeding season or temporarily displace some wildlife species.

The Deschutes LRMP Wildlife Standards and Guidelines that support these issue statements include: WL-1 --5, 11, 12, 19, 20, 28, 29, 31, 33, 34, 56, 72, and 73.

- Units of Measure:
  - Distance between drill sites and nesting sites.
  - Area of habitat removed.

Discussion of effects on wildlife from induced seismic events

This section is intended for those wildlife species brought forward for analysis and to put in context the unknown effects or potential effects from the proposed actions that would occur under Alternative A. The remaining sections disclose the logical or potential effects from known activities that would occur under Alternative A for each category of species. Although the referenced paper below focuses on grizzly bear, there is suitable habitat interspersed throughout the project area for black bears and other big game animals, such as deer, elk, and mountain lions.

A search of scientific literature was conducted by URS Corporation (URS) on the potential effects of induced seismic events on bird or mammal species. Based on this review, no documented effects were identified. While a magnitude 3.5 induced seismic event could result in acoustic, visual, and tactile stimuli that would be detectable by wildlife in the area in the form of short-duration, low-to-high frequencies of sound, and physical shaking, these stimuli may be masked by or mistaken for natural, ambient environmental conditions and may not induce a response in wildlife species. Depending on the timing and frequency of induced seismic events, their impact on large mammal species could vary from temporary disturbance to temporary displacement. The impact of induced seismic events on nesting birds could vary from stress abandonment or failure and mortality of eggs, fledglings and adults. However it is unknown whether the magnitude of disturbance birds might experience following an induced seismic event would be substantially different from the natural, ambient stimuli and, thus whether nest abandonment/failure or bird mortality is likely to occur.

One study[22] that did not appear in the scientific literature search conducted by URS looked at the effects of seismic surveys on denning bears in northern Alaska. Three radio-collared denning grizzly bears were monitored for heart rate changes before and after detonation of seismic shots 1.4-1.8 km away. The study found that the limited number of observations and the fact that bears show increased heart rates during undisturbed conditions limited the conclusions that could be drawn. The authors concluded that even if animals responded to noises associated with seismic exploration activities, effects on the bears were probably minimal. None of the radio-collared bears deserted their dens in response to seismic activities and all emerged in the spring with no observed deaths of accompanying offspring.

In a memorandum to AltaRock[23], URS concluded that the magnitude and intensity of the induced seismic events are anticipated to cause minimal temporary disturbance or displacement to nesting bird or large mammal species. Nest abandonment/failure or bird mortality is considered unlikely. In addition, the measures outlined in the ISMP (Appendix A), are designed to mitigate induced seismic events.

Threatened, Endangered, Proposed, and Candidate Species Discussion

- Oregon spotted frog and northern spotted owl

  Since there is no suitable dispersal, foraging, or nesting habitat within or adjacent to the proposed borehole sites or monitoring stations, Alternative A would have no effect on the northern spotted owl or Oregon spotted frog. The project area is also located outside the Northwest Forest Plan so the PDCs in the Programmatic BA do not apply. The vegetation within most of the proposed sites is either in early seral or early to mid-seral dry and wet lodgepole pine while some sites exhibit a mix of dry and wet mid-seral ponderosa pine/lodgepole pine, but they do not exhibit old growth mixed conifer stands (i.e. hemlock) including large diameter woody material. The nearest known northern spotted owls are approximately 16 to 18 miles west of the project area. There are also no streams or marsh within or adjacent to the proposed sites for Oregon spotted frog. Paulina Creek is the nearest stream (approximately 1/2 mile away from any proposed site), but the general area is considered too warm and dry for Oregon spotted frog. Paulina Lake and East Lake is within proximity of two monitoring stations, but there are no known records of

[22] Reynolds, Patricia E., Harry V. Reynolds, and Erich H. Follmann. 1986. Responses of grizzly bears to seismic surveys in northern Alaska. International Conf. Bear Res. and Manage. 6:169-175.

[23] Bettelheim, Matthew, URS Memorandum, 5 April 2011, Background review on the Potential Impacts to Wildlife from Induced Seismic Events Associated with the Newberry Volcano EGS Demonstration Project.

spotted frogs occurring in either of these two lakes. The nearest known populations of Oregon spotted frogs occur approximately 18 miles west of the project area.

- FISHER

  There is no suitable denning habitat within or immediately adjacent (a couple hundred feet) to the proposed sites, such as mature, greater than 60% closed-canopy coniferous forest with some deciduous component associated with riparian areas. However, this habitat description occurs along Paulina Creek. Paulina Creek is approximately ½ away from three of the project's proposed sites. Two of the sites are proposed drilling sites and the other is a monitoring station that would be accessed by foot. High recreational use such as camping and hiking occurs along Paulina Creek, therefore it is unlikely fishers would den in the area, but may be used for travel movement. The remaining vegetation interspersed between the rest of the monitoring stations is considered marginal or in many areas non-habitat. There are some pockets of montane mixed conifer between proposed sites that could provide suitable habitat, but there are no large blocks of continuous habitat for solitude. Currently, many human activities also occur within the areas of Paulina and East Lake, including a snowmobile trail north and east of the crater.

  It is unlikely that the 2/3 acre total of lodgepole pine that would be removed for the three borehole sites would impede travel to or from the Cascades. Since noise disturbance from drilling occurs out to about ½ mile, it is unlikely drilling would impede travel movement for fishers. Additionally, the dense vegetation and terrain changes between the creek and drill sites may act as a noise barrier to lessen the noise impact. Given there is a low probability of species occurrence in the area, the increased traffic and noise from the proposed activities in the short-term (up to 2 years) is not likely to have a measurable impact on movement.

- WOLVERINE

  Since there is no suitable denning habitat within or adjacent to any of the proposed activities, Alternative A would have no effects on habitat. Although wolverines have a much broader movement than fishers, they are also given a low probability of occurrence since there are no large blocks of continuous habitat for solitude, and due to the currently high recreational activities in the area. In addition, the majority of activities, noise and traffic would occur at the main pad, where much of the area has been logged and rather open. Overall, the slight increase in traffic along the major roads, and authorizing gate access to the main pad within the short-term is not likely to have an impact on movement.

REGION 6 SENSITIVE SPECIES DISCUSSION

The 2/3 acre total proposed for vegetation removal for preparing the three borehole sites is not considered suitable nesting habitat for any Region 6 sensitive species, therefore Alternative A would have no impact to nesting habitat in these three areas.

The most logical potential impact to sensitive species from Alternative A would be from additional human presence and/or noise disturbance in the area. If nesting occurs within ½ mile to any of the sites, drilling, increased traffic, and human presence has the

potential to cause nest failure if the species becomes intolerant to the activities. Typically, noise disturbance occurs within ¼ mile from nest sites for most species. Most of the noise disturbance would be concentrated at the S-29 site (up to 2 years), the 3 new borehole sites from drilling (up to 42 days), and any roads that would be utilized by work trucks, especially diesel engines. However, there are no known nests within ¼ or ½ mile of the sites and the habitat immediately adjacent to these four sites is not considered suitable habitat for any Region 6 sensitive species.

Suitable nesting habitat does occur interspersed between some sites for species, such as white-headed woodpecker and Lewis' woodpecker, but there are no known active cavities or nest sites within ¼ mile or ½ mile from any of the proposed monitoring sites.

In the last couple of years, there has been an active bald eagle pair that has been alternating nests between East Lake and Paulina Lake. With the exception of the two monitoring stations on the western flank of Paulina Lake, all of the other stations are 3 miles and/or beyond from the known nest sites; the two monitoring stations on the western flank of Paulina Lake are approximately 2 miles away and would be accessed by foot. Therefore, it is unlikely noise or human disturbance would have an impact on bald eagles.

The riparian area along Paulina Creek provides suitable habitat for species such as harlequin duck, northern waterthrush, or Crater Lake tightcoil. The proposed activities would not contribute to habitat removal in these riparian or lake areas. Due to its distance from the activities (approximately 1 mile from Well NWG 55-29 and 0.4 mile from the nearest MSA borehole stations) as well as the steep terrain and dense vegetation around Paulina Creek, any generated noise would be diffused and would not likely disturb these species.

There is no suitable nesting habitat for peregrine falcons within or interspersed within the planned activities. Although, foraging habitat may exist because there is suitable nesting habitat on Paulina Peak, which occurs over 2 miles to the northwest from the concentration of activities. High quality foraging habitat exists within the Paulina and East Lake areas due to the increased diversity of prey species (i.e. waterfowl and shorebirds), therefore it is unlikely the planned activities would have an impact or disturbance on peregrine falcon foraging.

Management Indicator Species Discussion

The total 2/3 acre removal of vegetation of early seral lodgepole pine at the three borehole sites does not provide nesting habitat for raptors, but may provide some form of habitat for certain MIS species, such as hiding cover for deer, or cover for American martens, or bird species. The total area of temporary habitat removal at each site would have a minimal impact on overall habitat for MIS species.

The total presence from the activities under Alternative A would occur up to approximately two years. A logical assumption could be made that the proposed activities may cause or has the potential to cause some form of noise disturbance to certain MIS (if present in the area) from the increased traffic and drilling noise. The sound levels from the proposed drilling under Alternative A are estimated to be up to 45

dBA at a distance of 0.5 miles. As stated in the affected environment section, all three known raptor nests are over ½ mile away from any project site requiring drilling. Drilling would be temporary, approximately 180 days at NWG 55-29, and 14 days at each of the 3 new borehole MSA sites (the habitats adjacent to these 3 borehole MSA sites are not considered raptor nesting habitat, nor are there known nests).

The vegetation, including various buttes interspersed throughout all 20 sites would act as a natural barrier to reduce noise disturbance to habitats during drilling or from traffic noise, therefore noise levels would vary from area to area. The following direction however is provided by the Deschutes National Forest Land and Resources Management Plan (USDA 1990) to minimize any potential impacts to nesting raptors:

> "Disturbing" activities will vary site specifically. Active raptor nest sites should be protected from disturbing activities within a ¼ mile (one mile for the use of explosives) of nests by restricting operations during the nesting periods. If the specified restriction period must be compromised, project activity at the end of the period (e.g. the last month or two) is least likely to cause nest abandonment.

Since the proposed noise is expected to be heard at ½ mile and the LRMP direction is ¼ mile, and depicts that disturbing activities will vary site specifically if nesting raptors are located within ½ mile of any of the activity sites, a wildlife biologist will make a determination if drilling would be timed to not occur during the breeding season for the following species:

- Bald eagle — January 1st – August 31st
- Osprey — April 1st – August 31st
- Redtail hawk — March 1st – August 31st
- Northern goshawk — March 1st – August 31st
- Cooper's hawk — April 1st – August 31st
- Sharp-shinned Hawk — April 1st – Aug. 31st
- Great gray owl — March 1st – June 30th

In view of the direct and indirect effects, and by applying the project design feature above, the proposed activities may still have a slight impact on some MIS species (i.e. unknown nests) from human disturbance and noise traffic, but it is expected to be short-term (2 years) and localized.

Migratory Birds Discussion

One of the consequences of industrial activity in forested environments is increased anthropogenic noise due to vehicles, machinery, and infrastructure (Bayne et. al 2008). Industrial noise can take many forms. Forestry and energy-sector operations can generate intense noise for periods of days to weeks in a relatively small area. It seems logical because of the importance of acoustic information to forest songbirds and the myriad number of ways anthropogenic noise can affect avian communication, that birds might avoid chronically noisy locations (Bayne et. al 2008). Bayne et. al 2008 compared the density and occupancy rate of forest passerines from noise-generating compressor stations and noiseless well pads in the boreal forest of Alberta, Canada. They found that

one-third of the species examined showed patterns that supported the hypothesis that abundance is influenced by anthropogenic noise.

This study was conducted at compressor stations that are part of the gas pipeline network and sites > 3km away from each other were selected to ensure noise from one site to another could not be heard. A compressor consists of 1-3 motors cooled by an equal number of large fan units housed in an insulated metal shed in a small clearing of about 2 – 4 ha, producing between 75 and 90 dB at the source, but can reach 105 dB at large facilities (MacDonald et al. 1996 in Bayne et. al 2008). Non-passerines (i.e. woodpeckers) were counted but excluded from all analyses.

Unlike the already established industry in Alberta, Canada, including continuous running compressor stations and the louder decibel output, the total presence from the activities under Alternative A would occur for approximately up to two years. A logical assumption could be made that the proposed activities may cause or have the potential to cause some form of disturbance to certain migratory birds (if present in the area) from the increased traffic and drilling noise. The sound levels from the proposed drilling under Alternative A are estimated to be up to 45 dBA at a distance of 0.5 miles. As described above, drilling would be temporary and vegetation and terrain changes would act as a natural barrier to reduced disturbance.

In view of the direct and indirect effects, the proposed activities may have a slight impact on some migratory bird species from noise disturbance, but it is expected to be short-term (2 years) and localized.

Determination of Effects to Federally Threatened, endangered, proposed, and candidate species, and Region 6 sensitive species

Below (Table 9) are each species Federal and Forest level status, the state of Oregon Natureserve rankings, and the determinations of effects from the biological evaluation (BE) for each alternative (Note: several species have several listings status). These determinations were made by reviewing the direct, indirect, and cumulative effects, including applying the project design features. While there may have been potential habitat interspersed between sites, adjacent to, or a couple of miles to the proposed sites for some species, the analysis was thoroughly conducted to reach these determinations. The BE was prepared based on presently available information. If the actions are modified in a manner that causes effects not considered, or if new information becomes available that reveals that the action may impact federally listed or sensitive species in a manner or to an extent not previously considered, a new or revised BE would be required which may include additional project design criteria.

Table 9: Summary of Determinations of Federally Threatened, Endangered, Proposed, and Candidate Species, and Region 6 Sensitive Species.

Species	Federal & Forest Level Status	Nature-serve Status	Alternative A	Alternative B	Alternative C
Northern Spotted Owl - *Strix occidentalis caurina*	T	S3	NE	NE	NE
Oregon Spotted Frog - *Rana pretiosa*	C,S	S2	NI	NI	NI
Pacific fisher - *Martes pennanti pacifica*	C,S	S2	NI	NI	NI
Wolverine - *Gulo gulo luteus*	C,S	S1	NI	NI	NI
Northern Bald Eagle - *Haliaeetus leucocephalus*	S,MIS	S4B,S4N	NI	NI	NI
American Peregrine Falcon - *Falco peregrinus anatum*	S, MIS*	S2B	NI	NI	NI
Bufflehead - *Bucephala albeola*	S	S2B, S5N	NI	NI	NI
Harlequin Duck - *Histrionocus histrionicus*	S	S2B, S3N	NI	NI	NI
Greater Sage Grouse - *Centrocercus urophasianus*	S*	S3	NI	NI	NI
Horned Grebe - *Podiceps auritus*	S	S2B, S5N	NI	NI	NI
Yellow Rail - *Coturnicops noveboracensis*	S*	S1B	NI	NI	NI
Tricolored Blackbird - *Agelaius tricolor*	S*	S2B	NI	NI	NI
White-headed Woodpecker - *Picoides albolarvatus*	S*, MIS, Landbird focal species	S2	MIIH	MIIH	NI
Lewis Woodpecker - *Melanerpes lewis*	S*, MIS, Landbird focal species	S2	MIIH	MIIH	NI

Species	Federal & Forest Level Status	Nature-serve Status	Alternative A	Alternative B	Alternative C
Northern Waterthrush - *Seiurus noveboracensis*	S	S2	NI	NI	NI
Pygmy Rabbit - *Sylvilagus idahoensis*	S	S2	NI	NI	NI
Townsend's Big-Eared Bat - *Corynorhinus townsendii*	S, MIS	S2	NI	NI	NI
Crater Lake tightcoil - *Pristiloma arcticum crateris*	S	S1	NI	NI	NI
Silver-bordered fritillary - *Boloria selene*	S	S2	NI	NI	NI
Johnson's hairstreak - *Callophrys johnsoni*	S	S2	NI	NI	NI
Key to abbreviations: E=Federally Endangered, T=Federally Threatened, C=Candidate for Federal listing, P=Proposed for Federal listing S=USFS Region 6 Sensitive; MIS=Management Indicator Species; ∗Birds of Conservation Concern come from the US Fish & Wildlife Service BCC – BCR 9 (Great Basin) [2008]; Landbird Focal Species come from the Conservation Strategy for Landbirds of the East-Slope of the Cascade Mountains in Oregon & Washington (Altman 2000); Oregon Sensitive Species determined from the Natureserve database for Oregon: S1, critically imperiled, S2 = imperiled, S3 = vulnerable, S4 = apparently secure, S5 = secure, B = breeding, N = non-breeding					
NE = No Effect; NI = No Impact; MIIH = May impact individuals or habitat, but will not likely contribute to a trend toward federal listing or loss of viability to the population or species; BI = Beneficial Impact					

Determination of Effects to Deschutes MIS and Migratory Birds

The following table (Table 10) shows the Deschutes National Forest Management Indicator Species and combined migratory birds list (see foot note at the bottom as a reference for each status description), including their preferred habitats. The species bolded in black were species whom had potential habitat or within the matrix of habitat between the 20 proposed sites (project area) and only those who may be potentially impacted from noise disturbance due to traffic and human presence. Although there may

be potential suitable habitat at Paulina or East Lake for many of the shorebirds or waterfowl species, there would be no impact to these species because the main site of project activity (NWG 55-29) and the three new borehole MSA drill sites would occur several miles away, west of the two lakes (note: Paulina Creek would not provide suitable habitat for these species and those that may have habitat at the creek were considered and analyzed). Lastly, due to the total 2/3 acre of habitat removal of early seral lodgepole pine, the most logical impact from the proposed project would be from noise disturbance and are grouped together in the Alternative A and B column. However, as previously stated in the analysis, Alternative B would have more impact than Alternative A due to additional required diesel engine trucks and longer duration of the activity. Alternative C (no action) would have no direct or indirect impact on any of these species.

Table 10: Deschutes National Forest MIS and Migratory Birds.

Species	Status	Habitat	Alternatives A and B
Northern goshawk	MIS S3 Vulnerable	Mature and old-growth forests; especially high canopy closure and large trees	Potential noise disturbance
Cooper's hawk	MIS S4 Apparently secure	Similar to goshawk, can also use mature forests with high canopy closure/tree density	Potential noise disturbance
Sharp-shinned hawk	MIS S4 Apparently secure	Similar to goshawk in addition to young, dense, even-aged stands	Potential noise disturbance
Great gray owl	MIS S3 Vulnerable	Mature and old growth forests associated with openings and meadows	Potential noise disturbance
Great blue heron	MIS S4 Apparently secure	Riparian edge habitats including lakes, streams, marshes and estuaries	Potential noise disturbance
Golden eagle	MIS, BCC S4 Apparently secure	Large open areas with cliffs and rock outcrops	
Red-tailed hawk	MIS S5 Secure	Large snags, open country interspersed with forests	Potential noise disturbance
Osprey	MIS S4 Apparently secure	Large snags associated with fish bearing water bodies	Potential noise disturbance
Elk	MIS S5 Secure	Mixed habitats	Potential noise disturbance
American marten	MIS S3 Vulnerable	Mixed conifer or high elevation late-successional forests with abundant down woody material	Potential noise disturbance

Species	Status	Habitat	Alternatives A and B
Mule deer	MIS S5 Secure	Mixed habitats	Potential noise disturbance
Snags and Downed Wood associated species and habitat	MIS	Snags and down woody material	
Pygmy nuthatch	Landbird focal species S4 Apparently Secure	Mature ponderosa pine forests and snags	Potential noise disturbance
Chipping sparrow	Landbird focal species S4 Apparently Secure	Open understory ponderosa pine forests with regeneration	Potential noise disturbance
Brown creeper	Landbird focal species S4 Apparently Secure	Large trees in mixed conifer forests	Potential noise disturbance
Flammulated owl	Landbird focal species, BCC S3B Vulnerable -breeding	Interspersed grassy openings and dense thickets in mixed conifer forests	Potential noise disturbance
Hermit thrush	Landbird focal species S4 Apparently Secure	Multi-layered/dense canopy in mixed conifer forests	Potential noise disturbance
Olive-sided flycatcher	Landbird focal species S3B Vulnerable -breeding	Edges and openings created by wildfire in mixed conifer forests	Potential noise disturbance
Common loon	MIS SHB, S5N – Possibly Extirpated-Breeding, Secure Non-breeding	Edges of remote freshwater ponds and lakes	
Pied-billed grebe	MIS S5 Secure	Edge of open water in freshwater lakes, ponds, sluggish rivers and marshes	
Horned grebe	MIS S2B, S5N – Imperiled breeding, Secure –non-breeding	Open water with emergent vegetation	

Species	Status	Habitat	Alternatives A and B
Red-necked grebe	MIS S1B, S4N – Critically imperiled breeding, Apparently secure nonbreeding	Lakes and ponds in forested areas	
Eared grebe	MIS S4 Apparently secure	Open water with emergent vegetation	
Western grebe	MIS S3B, S2S3N – Vulnerable breeding, Imperiled/Vulnerable-nonbreeding	Marches with open water and lakes and reservoirs with emergent vegetation	
Canada goose	MIS S5 Secure	Variety of habitat: shores of lakes, rivers, and reservoirs especially with cattails and bulrushes	
Wood duck	MIS S4 Apparently secure	Cavity nester	
Gadwall	MIS S5 Secure	Concealed clumps of grasses in meadows and tall grasslands	
American widgeon	MIS S5 Secure	Clumps of grasses in meadows or tall grasslands	
Mallard	MIS S5 Secure	Open water with emergent vegetation	
Blue-winged teal	MIS S4 Apparently secure	Marshes, lakes, ponds, slow-moving streams	
Cinnamon teal	MIS S5 Secure	Cover of vegetation near shoreline	
Northern shoveler	MIS S5 Secure	Grassy areas near water	
Northern pintail	MIS S5 Secure	Open areas near water	
Green-winged teal	MIS S5 Secure	Freshwater marshes with emergent vegetation	
Canvasback	MIS S4 Apparently secure	Emergent vegetation	

Species	Status	Habitat	Alternatives A and B
Redhead	MIS S4 Apparently secure	Freshwater marshes and lakes concealed in vegetation	
Ring-necked duck	MIS S3 vulnerable	Thick emergent vegetation on shorelines	
Lesser scaup	MIS S3B, S4N – Vulnerable breeding, apparently Secure nonbreeding	Dry grassy areas near lakes at least 10 ft. deep	
Common goldeneye	MIS S4 Apparently Secure	Cavity nester	
Barrow's goldeneye	MIS S3B, S3N – Vulnerable breeding, Vulnerable-nonbreeding	Cavity nester	
Hooded merganser	MIS S4 Apparently Secure	Cavity nester	
Common merganser	MIS S4 Apparently Secure	Cavity nester	
Ruddy duck	MIS S4 Apparently Secure	Freshwater marshes, lakes, ponds in dense vegetation	
Woodpecker Species			
Williamson's sapsucker	MIS, Landbird Focal species, BCC	Mature or old growth conifer forests with open canopy cover; weak excavator	Potential noise disturbance
Red-naped sapsucker	MIS S4 Apparently Secure	Riparian hardwood forests	
Downy woodpecker	MIS S4 Apparently Secure	Riparian hardwood forest	
Hairy woodpecker	MIS S4 Apparently Secure	Mixed conifer and ponderosa pine forests	Potential noise disturbance
Three-toed woodpecker	MIS S3 Vulnerable	High elevation and lodgepole pine forests	Potential noise disturbance
Black-backed woodpecker	MIS, Landbird focal species S3 Vulnerable	Lodgepole pine forests, burned forests	Potential noise disturbance

Species	Status	Habitat	Alternatives A and B
Northern flicker	MIS S5 Secure	Variety of forest types but more associated with forest edges	Potential noise disturbance
Pileated woodpecker	MIS S4 Apparently Secure	Mature to old-growth mixed conifer forests	Potential noise disturbance
Swainson's hawk	BCC	Open country	
Ferruginous hawk	BCC	Open sagebrush flats; open country	
Prairie falcon	BCC	Rimrock, cliffs in open country	
Greater sage grouse	BCC	Sagebrush flats	
American golden plover	BCC, Shorebird	Upland tundra, rare in OR in dry mudflats, fields and pastures	
Snowy plover	BCC, Shorebird	Sandy beaches	
American avocet	BCC	Shallow water	
Solitary sandpiper	BCC, Shorebird	Small, freshwater mudflats	
Whimbrel	BCC, Shorebirds	Grassy marshes and tidal flats	
Long-billed curlew	BCC, Shorebird	Dry grasslands	
Marbled godwit	BCC	Expansive mudflats and sandflats on beaches	
Sanderling	BCC, Shorebird	Sandy beaches with wave action	
Wilson's phalarope	BCC, Shorebird	Shallow ponds within grassy marshes	
Yellow-billed cuckoo	BCC	Riparian hardwoods	
Burrowing owl	BCC	Open grassland or agricultural land	
Black swift	BCC	Damp coastal cliffs	
Loggerhead shrike	BCC	Open habitat with scattered trees and shrubs	Potential noise disturbance

Species	Status	Habitat	Alternatives A and B
Gray vireo	BCC	Rocky, dry hillsides with scattered trees	
Virginia's warbler	BCC	Mountain mahogany	
Brewer's sparrow	BCC	Sagebrush habitats	
Sage sparrow	BCC	Sagebrush habitats	
Piping plover	Shorebird	Rare in OR on sandy beaches	
Mountain plover	Shorebird	Shortgrass prairies	
Buff-breasted sandpiper	Shorebird	Nests in tundra, forages on shortgrass prairie	
Black oystercatcher	Shorebird	Coastal rocks	
Upland sandpiper	Shorebird	Grassy fields (4-8" tall) with open patches	
Bristle-thighed curlew	Shorebird	Rare in OR in marshes or beaches. Nests in Alaska tundra	
Hudsonian godwit	Shorebird	Mudflats and shallow water; nests around spruce woods	
Marbled godwit	Shorebird	Prairie ponds, mudflats and sandflats	
Black turnstone	Shorebird	Tundra, winters on rocky, coastal shores	
Surfbird	Shorebird	Nests on barren gravel hilltops, winters on rocky shorelines	
Western sandpiper	Shorebird	Mudflats and sandy beaches	
Rock sandpiper	Shorebird	Rocky shorelines	
Short-billed dowitcher	Shorebird	Mudflats and shallow muddy ponds along coast	
American woodcock	Shorebird	Damp, brushy woods	
Wilson's plover	Shorebird	Rare in OR on sandy beaches, sandflats or mudflats away from shoreline	

Species	Status	Habitat	Alternatives A and B
American oystercatcher	Shorebird	Rare in OR on rocky coasts	
Bar-tailed godwit	Shorebird	Low tundra in western Alaska	
Ruddy turnstone	Shorebird	Rocky and sandy shorelines	
Red Knot	Shorebird	Sandy beaches	
Dunlin	Shorebird	Sandy beaches and mudflats	
Calliope hummingbird	BCC	Open montane forest, mountain meadows, and willow thickets	Potential noise disturbance
Black swift	BCC	Waterfalls, wet cliffs, caves	
Sage thrasher	BCC	Juniper, sagebrush shrublands. Mt. mahogany and aspen	
Nashville warbler	BCC	Open deciduous and coniferous woodland, forest edge and undergrowth	Potential noise disturbance
Black-chinned sparrow	BCC	Desert, shrubland/chapparal	
Willow flycatcher	BCC	Brushy areas with willow and riparian shrubs	Potential noise disturbance
Pinyon jay	BCC	Pinyon/juniper woodland	
Green-tailed towhee	BCC	Sagebrush shrublands	
Black rosy-finch	BCC	Alpine rocky, grassy areas	

Landbird focal species come from the Conservation Strategy for Landbirds of the East-Slope of the Cascade Mountains in Oregon and Washington (Altman 2000); **Management Indicator Species** come from the Deschutes National Forest Land and Resource Plan (LRMP)[1990]; **Birds of Conservation Concern (BCC)** come from the US Fish and Wildlife Service Birds of Conservation Concern – BCR 9 (Great Basin) [2008]; and **Shorebird*s*** come from the 2004 US Fish and Wildlife Service U. S. Shorebird Conservation Plan.

Scenic Resources Key Issue

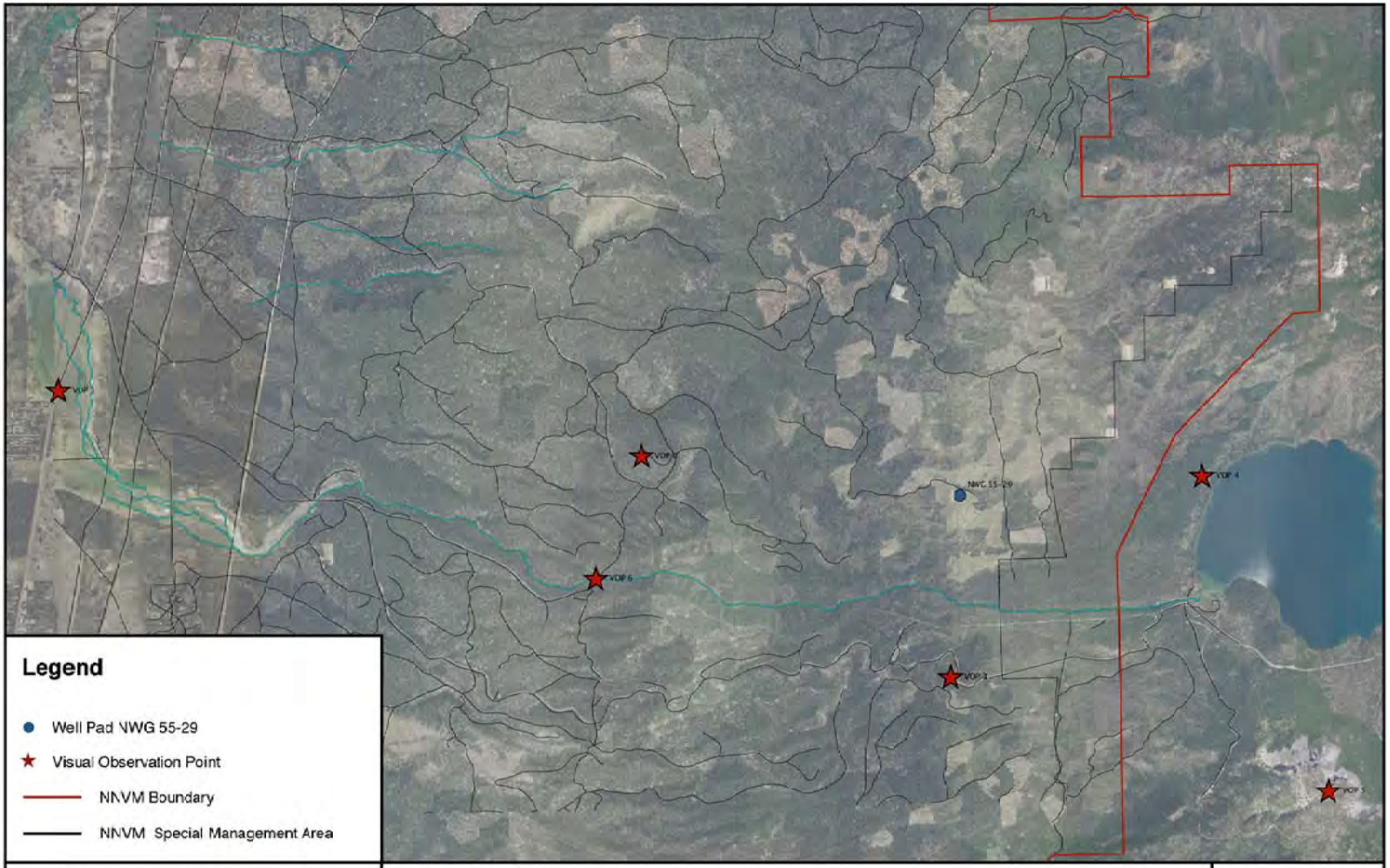
Removal of vegetation on the microseismic monitoring sites has the potential to cause up to 3 areas of approximately 9,375 square feet (0.2 acre) each or a total of 28,125 feet (2/3 acres) to not meet the Forest Plan standards for visual quality as seen from selected viewpoints. The Deschutes LRMP Standards and Guidelines that supports this issue statement is M8-19. The venting of steam during the short and long term circulation tests may also create a steam plume that could potentially be visible at times from certain selected viewpoints. The drill rig and circulation testing facilities may be visible at times from some key viewer locations during the anticipated 2-year duration of the Project.

- Units of Measure:
  - Number of sites and size in acres of areas that would have vegetation removed sufficient to be seen from key viewer locations.
  - The distance from selected viewpoints and ability to be seen by Forest visitors.

Discussion

Six key Viewpoints of Concern were selected as the most representative viewpoints in the project area for travelers and recreationists and have been considered for comparison of impacts and consequences for each action alternative. Other than Paulina Peak, most of the viewpoint positions are lower in elevation or at about the same elevation as the proposed Project sites. Refer to Figure V-3 for the locations of each visual observation point (VOP) and its relationship to the primary activity site (Pad S-29) for the Project.

- VOP 1: U.S. Highway 97 between mileposts 150 and 167
- VOP 2: McKay Butte
- VOP 3: Forest Road 21 Viewpoint
- VOP 4: Newberry Crater Rim Trail #57
- VOP 5: Paulina Peak summit
- VOP 6: Paulina Creek Trail #56



PLS Environmental

Viewpoints of Concern

Figure V-3

Figure 20 to Figure 25 are photographs taken from each of the six viewpoints, looking toward the nearest proposed Project site. These photos provide representation of a typical view from each viewpoint and demonstrate the dominant visual features seen by a visitor.

Figure 20: VOP 1 U.S. Highway 97 (Looking East)

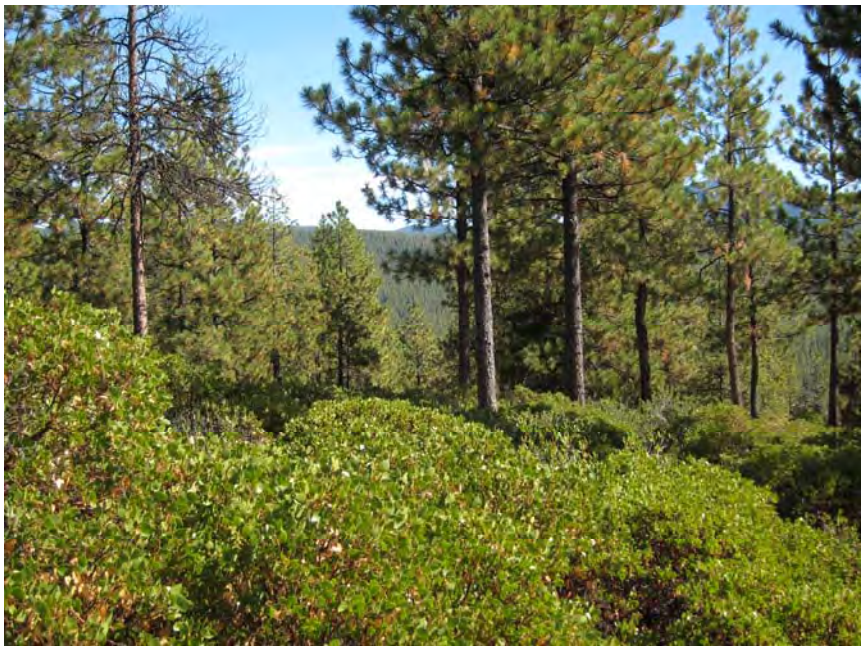


Figure 21: VOP 2 Mckay Butte (Looking East)

Figure 22: VOP 3 Forest Road 21 Overlook (Looking North)

Figure 23: VOP 4 Trail 57 – Crater Rim Trail (Looking West)

Figure 24: VOP 5 Paulina Peak (Looking Northwest)

Figure 25: VOP 6 Paulina Creek Trail 56 (Looking West)

Impacts to scenic resources from Alternative A would be short-term and primarily associated with dust from traffic on unimproved Forest roads, use of existing well pad S-29, removal of vegetation and site preparation at the new borehole sites, and the steam plume during venting.

The drill rig on existing well pad S-29 would likely be visible from higher viewpoints in the area including Paulina Peak, the viewpoint with the greatest number of visitors annually. Depending on weather conditions, a vapor plume would also be visible. Plume height and duration is dependent upon weather conditions with cool, clear days being more suitable for plume creation and warm, windy, cloudy days being less suitable for plume formation. As such, a plume would be more visible during the fall and winter months and less visible during late spring and summer months when visitor use is higher. Since the circulation test is estimated to take approximately 2 months to complete, visitors to Paulina Peak could see the visual impact for the same period of time. Since these impacts are of short duration and intensity, the impacts to a forest visitor would be similar to that experienced from a small prescribed fire, which is common within and around the surrounding landscape and occurs during the same time period.

Of the three new borehole MSA sites, one (NN19) is located within the MA-9 Partial Retention Middleground scenic views area and two (NN17 and NN24) are located in MA-8 Modification/Maximum Modification area.

Except for the steam plume, project facilities and activities of the Proposed Action would not be visible from most visual receptors, including the six VOPs, and would not affect sensitive visual resources. For each of the three new boreholes (NN17, NN24, and NN19) approximately 9,375 square feet (0.2 acre) of forest landscape would be disturbed during site preparation. Drilling operation at each of these boreholes would require a drilling rig, water truck, and mud tank on site. The existing borehole sites (TG17, TG19, TG 30, TG32, NN18, NP03, NN21) would not require surface preparation, but would have the same drilling activity if existing wells on those sites could not be utilized. Once drilling is completed, a solar panel (approximately four by four feet on a seven feet tall pole) would be installed and a small data gathering box would be installed on the solar panel pole. A 3 ft. long telemetry antenna would be placed on a pole or in a nearby tree. All other monitoring equipment would be placed inside the borehole and would not be visible on the surface.

For the 10 surface MSA sites, there would be no new surface disturbance for site preparation or well drilling, but surface monitoring stations would still be installed, equipment would be placed in a partially buried secured box, and a solar panel with recording equipment would be located on the site. A visitor standing immediately in front of a site may notice a 3ft. x 3ft. solar panel up in a tree or the partially buried box. None of this equipment would draw visual attention or affect visual resources.

Viewers at the Paulina Peak viewpoint may notice short-term indirect effects from the project such as the drilling rig during the two approximately 90-day drilling periods, or the steam plume during the approximate 60-day circulation test. During the summer, dust may be created from site preparation of new boreholes and by traffic along access roads and at pad S-29 that may draw some visual attention. The Proponents would water the roads using a water truck for dust abatement, which would alleviate most of this. Steam from venting would be visible, primarily during the 60 day circulation test, particularly during cold clear days, and may draw visual interest from a viewer at

Paulina Peak. The upper portion of the drill rig on pad S-29 may also be visible to a viewer at Paulina Peak; however, the use of drilling rigs were previously analyzed and approved in the 2007 geothermal exploration project. Due to numerous other significant features (lakes, lava flows, etc.) which readily draw visitors' attention at Paulina Peak, plus the topography, screening from vegetation, and the distance from the project, the casual observer would notice very little or none of the Project while visiting Paulina Peak or any other viewpoint.

None of the new borehole sites would be discernible in the landscape from any of the viewpoints, due to the small size, distance, and because the sites were specifically selected to blend in with the surrounding setting. Although the existing well pad and drilling activities were analyzed and approved in the 2007 EA, they may be seen from Paulina Peak but would be difficult to discern by the average viewer.

Steam venting was also analyzed and approved in the 2007 exploration EA, though venting from proposed EGS activities could be of longer duration (60 days vs. 30-45 days) than that already approved. The EGS venting activity would create a steam plume that could be seen from Paulina Peak and be partially visible from McKay Butte, the overlook on Forest Road 21, and by hikers traveling on some segments of the Rim Trail (TR #57). Viewers at the most distant VOP, U.S. Highway 97, could see a portion of the plume, but given the distance and limited viewing time, the plume would be visually subordinate in that setting. The steam plume would be visible on a clear day when viewed from all the VOPs other than VOP 4 (Crater Rim Trail) and the VOP 6 (Paulina Creek Trail) but would not be readily observed in cloudy or overcast weather conditions and would blend in with natural clouds.

Adopted in 1994, Amendment Number Three of the Forest Plan addresses visual aspects by modifying management area visuals to allow for a geothermal steam plume. This amendment was added to address the situation that a geothermal steam plume was not specifically considered during the LRMP process and that it may exceed the classification of Partial Retention, particularly when viewed from Paulina Peak. This amendment was adopted to address and allow a larger, long-term (50 years), and constant steam plume from an operating 33-megawatt geothermal power plant which had been proposed at a site near the EGS Project. In comparison, a steam plume from the EGS demonstration would be smaller and only of short duration (several months as opposed to 50 years), given that the EGS venting would be from only one or two wells and a circulation test facility and only for a limited time period.

Equipment used may create reflections, but this would be of no more consequence or importance than it would be for other vehicles or equipment on the Forest. Reflections have never been known to be a concern for any temporary Forest activity, including past geothermal exploration projects.

Table V-2 displays a summary of visibility from each VOP location.

Table V-2. Viewpoints of Concern Summary

Viewpoint No.	**Viewpoint Location**	**Jurisdiction**	**Elevation (feet)**	**View Direction (Viewpoint to Project)**	**Viewer Position**[1]	**View Distance to 55-29 (mi)**	**Project Facilities Seen**[2]				
							Pad S-29	**NN17**	NN24	NN19	Steam Plume[3]
VOP 1	U.S. Highway 97	Private	4,249	East	I	7.6	N	N	N	N	Y
VOP 2	McKay Butte	USFS	5,250	East	I	2.7	N	N	N	N	P
VOP 3	Forest Rd. 21 Overlook	USFS	5,841	North	N	1.5	N	N	N	N	P
VOP 4	TR 57-Crater Rim Trail	NNVM (USFS)	6,591	West	S	2.0	N	N	N	N	N
VOP 5	Paulina Peak	NNVM (USFS)	7,947	Northwest	S	4.0	Y	P	P	P	Y
VOP 6	Paulina Creek TR 56	USFS	4,800	North	I	3.0	N	N	N	N	N

[1]S – Superior, N – Normal, I – Inferior

[2]N – Not Visible, Y – Visible, P – Partially Visible

[3]Steam Plume Visibility – would be partially visible for either action alternative

Scenic Resources Summary

Very little, if any, of the project facilities and activities would be seen by average visitors at any of the six key VOPs, primarily due to the very small scale of the proposed Project (less than 2/3 acre of new ground disturbance) and its relationship to the surrounding landscapes that have Moderate to High Visual Absorption Capability. Some activity could be noticed from Paulina Peak and McKay Butte under certain circumstances, such as when the wells or circulation test facility is venting on a clear day.

The proposed Project would be in compliance with Forest Plan direction and Scenic Management Objectives for both General Forest and Scenic Views management areas.

Once the Project activities in Alternative A are completed, disturbed areas are not likely to draw any visual concern. The steam plume would no longer exist, trees would be planted where necessary to feather edges of the created openings at the three new borehole sites, further reducing any line, texture, or color contrast. All of the borehole sites are within proposed timber harvest units or vegetation treatment areas of the Ogden Vegetation Management project. As a result, any visual effects related to ground disturbance, vegetation clearing, and site preparation for the boreholes would be virtually unnoticeable within 5 years.

Groundwater Quantity Key Issue

Withdrawal of groundwater from water wells for the development and testing of a belowground EGS reservoir has the potential to reduce the quantity of water within the Deschutes drainage basin.

- Units of Measure:
  - Total amount of groundwater to be withdrawn in millions of gallons and rate of groundwater to be withdrawn in millions of gallons per day.

Groundwater Quality Key Issue

The development and testing of a belowground EGS reservoir has the potential to negatively impact groundwater quality within the aquifer.

- Units of Measure:
  - Amount, type of additives and depth at which they are to be injected. Injection and production well design features to prevent contamination of groundwater aquifer.

Discussion

The following discussion of potential effects to the hydrologic system in the Project area is primarily based on a recent report written by Kleinfelder (2011)[24]. This independent hydrologist review report is included as Appendix B.

Groundwater Quantity

The proposed action in Alternative A is estimated to require the use of up to 142 million gallons of water over a period of approximately 2 years, all of which is considered as consumptive use (Table 11). The project will rely on groundwater from the shallow aquifer present beneath the western flank of Newberry volcano to meet its water supply demands. As discussed in Section 3.6, this shallow aquifer is not in direct hydraulic connection with the La Pine sub-basin which is over 4 miles away and where the closest residents draw their water. There are currently two existing water supply wells available to supply water, the Pad S-29 water well (DESC 58395) and the Pad S-16 water well (DESC 58649). These two water wells are expected to supply all of the water demand during the demonstration project.

Water Rights

The Proponents have obtained a limited use license (LL-1347) from the Oregon Water Resources Department (OWRD) in order to use groundwater from these two wells. Groundwater mitigation credits will be purchased from the Deschutes Groundwater Mitigation Bank, operated by the Deschutes River Conservancy (DRC), in accordance with the OWRD permit. The DRC's groundwater mitigation bank creates temporary credits through instream leases. This leasing program allows landowners who do not wish to use their water rights the option to temporarily leave their water in the river for the purpose of enhancing stream flows. New groundwater users purchase these credits annually to mitigate for their water use. As a result, these instream leases would offset any loss of groundwater recharge due to the consumptive use of the project and there would be no net loss of water to the Deschutes river basin (Kleinfelder 2011).

[24] Figures and references noted in this section may be found in the report in Appendix B.

Table 11: Maximum Water Use Estimate for All Major Activities in the Newberry EGS Demonstration

Activity	Estimated Water Usage Rate, gpm	Maximum Water Volume, gal	Maximum Water Volume, acre-ft	Duration, days
Single well stimulation[1]	800	24,192,000	74.2	21
Rig use during stimulation[2]	-	210,000	0.6	21
Drilling producer #1[3]		3,152,150	9.7	90
Drilling producer #2[3]		3,152,150	9.7	90
Connectivity test PW1[5]	455	4,583,439	14.1	7
Dual well stimulation PW1[4]	1600 (split between 2 wells)	11,520,000	35.4	5
Connectivity test PW2[5]	455	4,583,439	14.1	7
Dual well stimulation PW2 [4]	1600 (split between 2 wells)	11,520,000	35.4	5
Circulation Test[6]	912	78,782,765	241.8	60
Total		141,695,942	435	

[1]This uses Soultz GPK2 stimulation volumes and multiplies it by three to achieve our desired network size.

[2]Assumes rig is sitting idle during 21 days of stimulation operations and requires less than 10,000 gpd of water for standby operations.

[3]Davenport Power used 19.4 acre-ft when drilling both well 55-29 and 46-16. BLM assumes that usage would be similar during the proposed project.

[4]The dual well stimulation assumes pumping simultaneously at 800 gpm into two wells for a maximum total time of 5 days.

[5] The connectivity tests between the injection well and each individual producer are planned for a duration between 3 and 7 days. It is assumed that 16.3 to 37.6% of the flashing fluid will be lost to the atmosphere. Additionally, it is assumed that 2% of the injected volume is never recovered due to leak-off in the reservoir. The numbers above reflect a water usage rate of 455 gpm for a full 7 days with 37.6% of evaporative steam loss.

[6] The long-term circulation test is planned to last 30-60 days. It is assumed that 16.3%-37.6% of the production fluid will be lost to the atmosphere. Additionally, it is assumed that 2% of the injected volume is never recovered due to leak-off in the reservoir. The high end estimate is listed above and it represents 37.6% evaporation for a 60 day test.

ESTIMATED WATER USE BY YEAR

An estimated timeline for the occurrence of major project events, as well as event durations, is outlined in the timeline below (Figure 26). The water use schedule shown begins in October 2012 with the stimulation of NWG 55-29, which will utilize approximately 74.2 acre-ft over a 21-day period[25]. Following the stimulation, a three-day flow-back test of 55-29 would be conducted. This task does not use any additional make-up water. In Summer 2013, drilling of the first of two production wells would begin. Based on Davenport's experience, the Proponents expect that each well would require 90 days to drill and 9.7 acre-ft of groundwater. Following the completion of each producer, the connection between the injector and the producer would be tested for up to 7 days and if necessary, a 5-day stimulation to enhance that connection would be conducted. Finally, a three-well circulation test between the injector and newly-drilled producers would commence in February 2014. The circulation test is scheduled to last between 30 and 60 days and require up to 242 acre-ft of groundwater. Figure 27 presents the projected monthly water usage between October 2012 and March 2014.

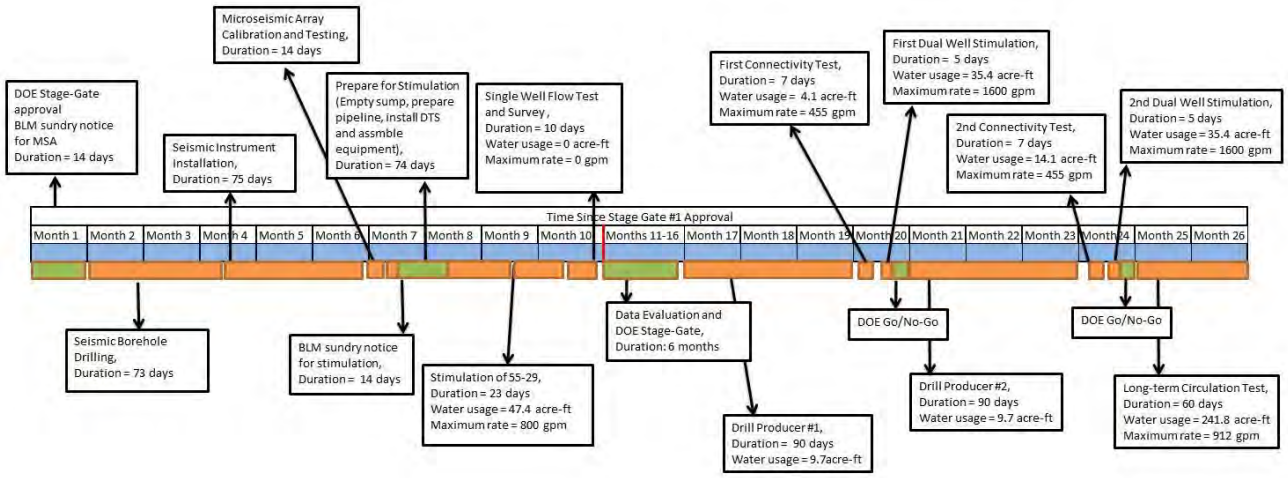


Figure 26: Major Events and Durations of Water Use.

[25] Prior to stimulation, a relatively small amount of water (up to 126,000 gals) would be used to drill the MSA boreholes over a 6 week period estimated to begin in February.

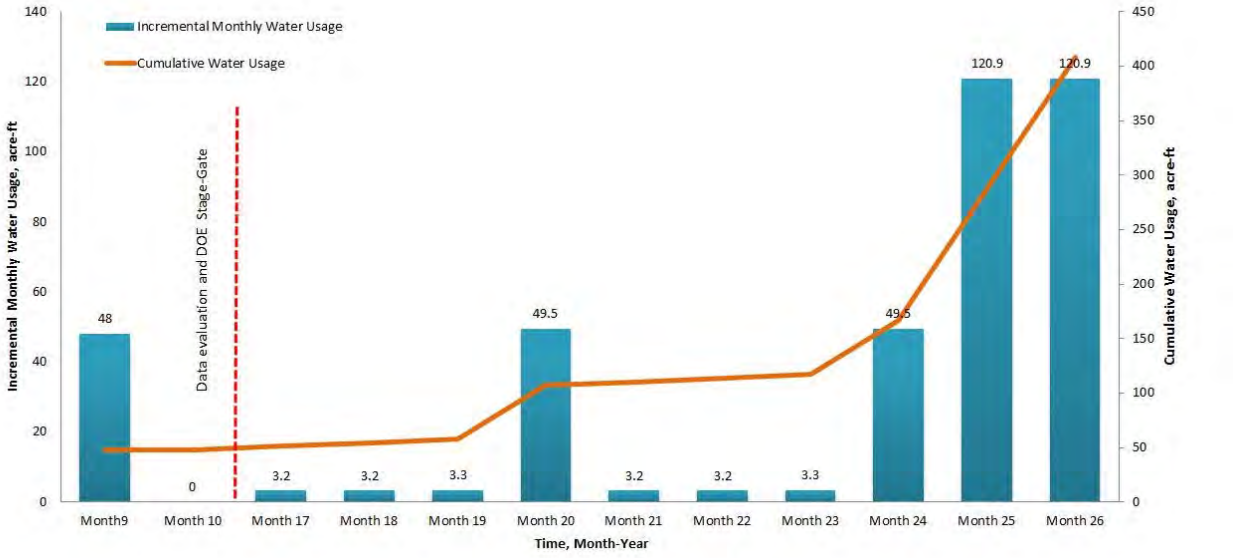


Figure 27: Water Usage By Month.

The direct effects on the groundwater resource are the anticipated temporary drawdowns near the existing water supply wells. Previous pumping tests on the water supply well on pad S-29 have provided some preliminary information on aquifer properties and the direct effects that could occur during the project. The most recent pumping test at the S-29 water well had no readily apparent effect upon the water level in the nearest observation well (the water well at S-16, 1.8 miles away). While the test was of shorter duration than the length of time the well would be pumped during stimulation the hydrologist report concludes that the water well appears to be supportive of prolonged pumping durations and that the aquifer appears to be adequate to supply sufficient water for the Project.[26] Aquifer testing indicates a relative steep cone of depression around the water supply well and a small (less than 2,500 feet) radius of influence (amount of water level drawdown as one moves away from the well).[27] Given that the closest water well is one mile away (a water well owned by the Proponents that will be used to monitor groundwater levels) no direct impacts to groundwater quantity in the immediate area are anticipated.

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[26] Aquifer Pumping Test Report Pad S-29 Water Well Newberry Volcano EGS Demonstration Project, Wallace Group, 2011, Appendix B p. 8-9.

[27] Report Independent Hydrologist Review EGS Demonstration Project, Kleinfelder, 2011, p. 7.

The indirect effects would be potential connection between the EGS reservoir and the local and regional aquifers, and impacts to surface water bodies. The planned EGS reservoir created through hydroshearing at the pad S-29 site will be a network of fractures extending approximately 1,500 feet radially. If these fractures extended upward from the top of the EGS reservoir zone, it would be several thousand feet below the bottom of the local and regional aquifers. Given the very low permeability of the receptor rock throughout the length of the vertical borehole below the regional aquifer, there is little chance that fluids would be able to migrate vertically during the testing period.

The conceptual hydrogeologic model indicates that Paulina Creek is in direct connection with the shallow aquifer present beneath the western flank of Newberry volcano, but above the Paulina-East Lake Road crossing at RM 5.2 (Figure 11, Sec. 3.6), the stream loses approximately 0.75 cfs/mile to groundwater (Morgan and others, 1997). Current aquifer testing in the project vicinity (Schwartz and others, 2010) indicates a relatively low transmissivity aquifer which would indicate a relative steep cone of depression around the water supply well and a small (less than 2,500 feet) radius of influence (amount of water level drawdown as one moves away from the well). These conditions further imply that the pumping of the water supply well on pad S-29 will not impact flows in Paulina Creek.

The only other surface water bodies in or near the Project area are Paulina and East Lakes. Since the base of the caldera lakes is topographically higher than the shallow aquifer present beneath the western flank of Newberry volcano, they would not be impacted if the shallow aquifer system inside the caldera was not impacted. In addition, the caldera's lakes are located hydrologically upgradient of the test site, making it that much more unlikely that a connection could occur.

The maximum water use proposed by the Project is 141,750,000 gallons or 435 acre-feet. This represents approximately three-tenths of one percent (0.003) of the estimated annual recharge (73 billion gallons or 224,000 acre-feet) to the Deschutes Basin from the west flank of Newberry volcano (Kleinfelder 2011, p. 15). The water supply wells for the project are licensed by the Oregon Water Resources Department (OWRD). Groundwater mitigation credits will be purchased from the Deschutes Groundwater Mitigation Bank, operated by the Deschutes River Conservancy in accordance with the OWRD permit. As a result there would be no net loss of water to the Deschutes river basin.

The closest beneficial use wells are located around Paulina and East Lakes at campgrounds. These wells tap shallow aquifers that are not in direct hydraulic connection with the water that will be used for the demonstration project. The other, nearby, local beneficial use aquifer is located in La Pine sub-basin which is over 4-miles away. These aquifers are not in hydraulic connection with the shallow aquifer present beneath the western flank of Newberry volcano at the Project site. Therefore no indirect effects to groundwater quantity in the Project area are anticipated.

Based on the current understanding of the hydrologic system in the La Pine sub-basin, the aquifer underlying the western flank of Newberry volcano is in direct continuity and

recharges the regional aquifer of the Deschutes Formation. Groundwater withdrawal for the Project will not be from the La Pine sub-basin aquifer, which supplies water to shallow wells in La Pine.

Because there are no other reasonably foreseeable projects in the area that would use large quantities of water and there are no anticipated direct or indirect effects from the project on water resources in the area, the cumulative effects on the hydrologic environment from groundwater pumping or injection during the EGS Demonstration Project are not considered likely based on the reasons cited above.

Groundwater Quality

The amount, type of additives, and depth at which they are to be injected will be discussed. Additionally, injection and production well design features to prevent contamination of the groundwater aquifer will also be described.

Materials Added at Each Stage

1. During stimulation:
    a. Tracers – thermally-reactive, sorptive, diffusive, and conservative fluid tracers that are injected intermittently during the stimulation as pulses. In a typical tracer test during stimulation, 25 kg each of one or more 'reactive' tracers and one conservative tracer are mixed with approximately 100 gal of water and injected as a pulse over a duration of a few minutes (a reactive tracer decays with time, while conservative tracers remain constant over a given period of time). The pulse is then followed by one or more wellbores of water in order to disperse the tracer throughout the near-wellbore reservoir formation. After a shut-in period that may extend for several hours to a few days, the well is made to flow back and the tracer concentrations are measured at the wellhead. An inversion of a numerical flow model based on tracer data is then used to estimate the near-wellbore fracture surface area. The tracer concentrations will be approximately 10 to 100 parts per thousand in the injected pulse, and approximately 0.1 to 100 parts per billion when produced at the wellhead. These tracers are typically detectable at the part per trillion level. For each tracer test used during stimulation, only 25 kg of one conservative tracer (a naphthalene sulfonate) will be used in combination with 25 kg of one to three reactive tracers (e.g., rhodamine WT, 1,3,6,8-pyrene tetrasulfonate, or safranin T). Eight naphthalene sulfonate tracers were listed in Table 12 but only 4 will be used during the three stimulation experiments and the one circulation experiment. Eight of the ten tracers that will potentially be used during the Demonstration are commonly used to monitor groundwater aquifers (Table 12).

b. Diverters – solid material that is injected in slugs between each stimulation stage[28].
c. Friction reducer – The Proponents don't expect to use friction reducers in the stimulation fluid, but it is an option if surface pressures need to be reduced. Typically, FR26-LC is used to reduce pipe friction at higher pumping rates. FR26-LC is a hydro-treated, light petroleum distillate that is added at concentrations of 0.5-1.0 gallons per million gallons of water. See product bulletin below.

2. During production well drilling:
   a. Mud additives – see well 55-29 mud report in the appendix. It is assumed that very similar mud additives will be used in the drilling of the two production wells.
3. During circulation and connectivity testing:
   a. Tracers.
   b. Friction reducer – FR26-LC or similar.

Table 12: Tracer Additives to System throughout Newberry Demonstration Project

Additive Name	Type of Additive	Time of Use	Quantity Injected	Concentration	Breakdown Products
*1,5-naphthalene disulfonate, disodium	tracer	Stimulation	25 kg	Variable	1,5-naphthalene disulfonate anion, Na^+
*2,6-naphthalene disulfonate disodium	tracer	Stimulation	25 kg	variable	2,6-naphthalene disulfonate anion, Na^+
*1,6-naphthalene disulfonate disodium	tracer	Stimulation	25 kg	variable	1,6-naphthalene disulfonate anion, Na^+
*2,7-naphthalene disulfonate disodium	tracer	Stimulation	25 kg	variable	2,7-naphthalene disulfonate anion, Na^+
*1-naphthalene sulfonate disodium	tracer	Stimulation	25 kg	variable	1-naphthalene sulfonate anion, Na^+
*2-naphthalene sulfonate disodium	tracer	Stimulation	25 kg	variable	2-naphthalene sulfonate anion, Na^+

[28] AltaRock has a portfolio of patent filings protecting its proprietary technology and methods.

Additive Name	Type of Additive	Time of Use	Quantity Injected	Concentration	Breakdown Products
*1,3,6,8-pyrene tetrasulfonate tetrasodium	tracer	Stimulation	25 kg	variable	1,3,6,8-pyrene tetrasulfonate anion, Na^+
Safranin T disodium	tracer	Stimulation	25 kg	variable	Safranin T anion, Na^+
*Rhodamine WT disodium	tracer	Stimulation	25 kg	variable	Rhodamine WT anion, Na^+
*Lithium Bromide	tracer	Stimulation	100 kg	variable	Li^+, Br^-
*Cesium Bromide	tracer	Stimulation	100 kg	variable	Cs^+, Br^-
*Rubidium Bromide	tracer	Stimulation	100 kg	variable	Rb^+, Br^-
*Lithium Iodide	tracer	Stimulation	100 kg	variable	Li^+, I^-
*Cesium Iodide	tracer	Stimulation	100 kg	variable	Cs^+, I^-
*Rubidium Iodide	tracer	Stimulation	100 kg	variable	Rb^+, I^-
*1,3,5-naphthalene trisulfonate trisodium	tracer	Circulation Testing	100 kg	variable	1,3,5-naphthalene trisulfonate anion, Na^+
*1,3,6-naphthalene trisulfonate trisodium	tracer	Circulation Testing	100 kg	variable	1,3,6-naphthalene trisulfonate anion, Na^+
*Fluorescein disodium	tracer	Circulation Testing	50 kg	variable	Fluorescein anion, Na^+
safranin T disodium	tracer	Circulation Testing	100 kg	variable	Safranin T anion, Na^+

*Denotes tracers that are commonly used in groundwater aquifer monitoring.

- For each tracer test used during stimulation, only 25 kg of one conservative tracer (a naphthalene sulfonate) will be used in combination with 25 kg of one to three reactive tracers (e.g., rhodamine WT, 1,3,6,8-pyrene tetrasulfonate, or safranin T).
- Only four naphthalene sulfonate tracers will be used during the three stimulation experiments and the one circulation experiment.
- Eight of the ten tracers that will potentially be used during the Newberry project are commonly used to monitor groundwater aquifers.

DIVERTERS

The purpose and use of diverters in EGS stimulation is covered in the description of the proposed action in Chapter 2.3. The amount and type of material is discussed below.

Proprietary diverters primarily developed by AltaRock would be used in the Newberry EGS Demonstration between pumping of the stimulation treatments for each fracture set. Diverter materials are selected to be benign and to have benign breakdown products. The diverters will be selected from two classes of materials: biodegradable plastics and naturally occurring minerals. Biodegradable plastics are plastics that will decompose in natural aerobic (composting) and anaerobic (landfill) environments. They may be composed of either bioplastics, which are plastics with components derived from renewable raw materials, or petroleum-based plastics which utilize an additive. The use of bio-active compounds, compounded with swelling agents, ensures that, when combined with heat and moisture, they expand the molecular structure of the plastic and allow the bio-active compounds to break the polymer chains into their component, soluble parts. These smaller components can then be metabolized if they are in the biosphere.

For example, one of the diverter materials made from renewable biologic raw materials that AltaRock has used is BioVertTM, a polymer of lactic acid, or PLA. This material is a hard plastic which is available as grains which can be sorted by size. When heated, the chains in the polymer break down to lactic acid, a soluble substance found in human and animal tissue as a normal product of metabolism and exercise. Three of the other biodegradable plastics which could be used on the Project are also made from biologic materials. Two others are derived from petroleum, but break down into small components that are bioactive and can be metabolized in the environment.

Biodegradable plastics would be selected based on the temperature at which they melt and then the temperature at which they dissociate.

The wells at Newberry are very hot, but will be cooled by injecting water for the stimulation. The diverter material selected needs to stay in place long enough to stimulate the remaining zones. The first zone stimulated may not be cooled enough to make it possible to use a biodegradable plastic as a diverter. If this is the case, one of the mineral diverters would be selected for that zone.

The mineral diverters that may be used are all naturally occurring materials that would be ground to a specific particle size and mixed with clean groundwater to pump into the well. A variety of diverters have been selected for varying solubility over a wide range of temperature. One possible mineral that has been tested is calcium carbonate (calcite). Because any natural mineral material can have contaminants that are toxic, AltaRock uses materials that have been quality controlled and tested to have very low contaminants. For example, the calcite selected for use as a diverter is very pure, with greater than 99% calcium carbonate and less than 0.3% quartz.

Water will be pumped for about seven (7) days to stimulate each fracture set. Stimulation of at least three fracture sets is planned, for a total of twenty-one (21) days of pump time. When the desired water volume has been pumped and the target fracture

volume has been stimulated, a suspension of diverter particles in water will be mixed up and pumped into the well. The amount of diverter material is expected to be between 100-250 pounds per diverter treatment. The particles will be carried down to the fractures that are currently accepting water. The particles will pack off in the fractures at the well bore face and seal off additional flow into the fractures (Figure 6). Additional pump pressure will be applied and a new set of fractures, typically below the first set of fractures, will be stimulated by hydroshearing. Pumping will continue until the second fracture set grows to the target volume. This process will be repeated again to stimulate a third fracture set.

Handling and Storage of Diverter Materials

Diverter materials are granular solids of various particle sizes. Materials will be stored on location in sacks, drums or super sacks (one cubic meter polyethylene bags). Material will be protected from the weather with plastic wrap, covering, and storage in a protected area. A total of 1000-2000 pounds of each selected diverter will be on hand at the well location.

Composition of Potential Diverters and Their Degradation Products

Table 13 is a list of potential proprietary diverter materials that might be used in the Newberry EGS Demonstration. One or more of these proprietary products may be used during the Demonstration based on the results of ongoing proprietary site investigations and laboratory testing of diverter performance. The Proponents expect to pump three stimulation stages by using between 100-250 pounds of diverter between stimulations, with one diverter treatment pumped between the first and second stimulation, and another treatment pumped between second and third stimulation.

Table 13: Diverter Material and Expected Degradation Products (Altarock Proprietary)

Material	Class of Material	Composition of Degradation Byproducts
BioVert™	Biodegradable polymer	Lactic Acid monomers, dimers and trimers
AltaVert ™ 150	Biodegradable plastic from petroleum	Carbon dioxide and a diol. This formulation of the material does not contain bisphenol.
AltaVert 200	Magnesium mineral	Mg^{2+}, Cl^{-}, MgO
AltaVert 201	Magnesium mineral	Mg2+, $(SO_4)^{2-}$, MgO
AltaVert 250	Calcium Mineral	Ca^{2+}, $CO3^{2-}$, $HCO3^{-}$
AltaVert 300	Oxide glass	H_4SiO_4, H_3SiO^{4-}, OH^{-}, H^{+}, Na^{+}, Ca^{2+} Na_2O, CaO, Al_2O_3 , silica polymerization Tobermorite, $Ca_5Si_6O_{16}(OH)_2{\cdot}4H_2O$, reported as a solid residue

Material	Class of Material	Composition of Degradation Byproducts
AltaVert 301	Natural mineral	H_4SiO_4, H_3SiO^{4-}, OH^-, H^+, silica polymerization
AltaVert 151	Biodegradable bioplastic	Hydrolysis produces the corresponding hydroxyacids that are mostly non-toxic
AltaVert 152	Biodegradable cellulosic fiber	oligosaccharides and hexoses (mainly glucose)
AltaVert 153	Biodegradable bioplastic	glycolic acid

Injection, Production and Well Design Features

The planned EGS reservoir will be created at depths of approximately 6,500 to 10,000 feet below ground. The network of fractures will extend approximately 1,500 feet radially. Even if these fractures extended upward from the top of the EGS reservoir zone, it would still be several thousand feet below the bottom of the local and regional aquifers. Given the very low permeability of the receptor rock throughout the length of the vertical borehole below the regional aquifer, there is little chance that fluids would be able to migrate vertically during the testing period. Therefore, materials injected as part of the EGS demonstration would not have an effect on groundwater quality in the regional aquifer.

Both the existing well NWG 55-29 and two production wells to be drilled will be cased and cemented per BLM and DOGAMI regulations in order to prevent any chemicals from entering the groundwater. NWG 55-29 is a relatively young well and had a positive casing integrity test conducted in 2008. The caliper survey in 2008, temperature surveys in 2008 and 2010, and the maximum pressure profile achieved during the inject-to-cool operation in 2010, indicate the casing has retained its integrity. This will both protect groundwater resources and prevent degradation of the geothermal production fluid within the well bore. A cross section of well NWG 55-29 design is shown in Figure 28.

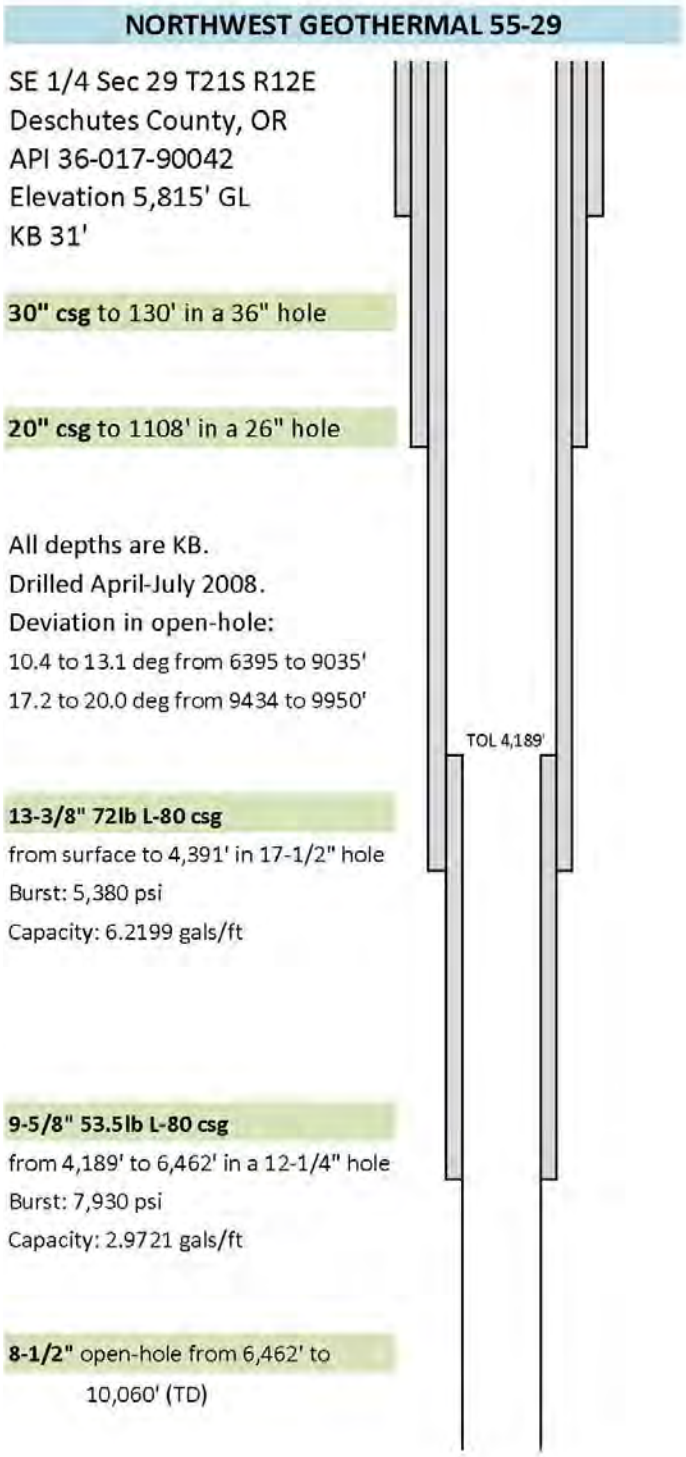

Figure 28: Davenport Well NWG 55-29 Well Bore and Casing Profile

Induced Seismicity Key Issue

The development of a below-ground EGS reservoir by hydroshearing has the potential to produce induced seismicity and increased seismic risk that could affect historic structures, resorts, and other recreation sites within the NNVM, could increase avalanche risk, could increase risk to above and below ground geologic features, and could result in property damage in nearby population centers.

- Units of Measure:
  - Probability of exceeding peak ground acceleration (PGA) above 0.028 g[29], due to EGS activities, calculated at well pad 55-29, Paulina and East Lake Resorts and campgrounds, Lava Lands Visitor Center, avalanche-prone sites on North Paulina Peak and Paulina Peak, and the nearest population centers of La Pine, Sunriver, and Bend.

Analysis

The International Energy Agency (IEA) developed a protocol for addressing induced seismicity during geothermal projects that was adopted by the U.S. Department of Energy (DOE) for EGS demonstration projects (Majer et al., 2008). The Proponents adapted this protocol to the geologic and environmental conditions for its Newberry EGS Demonstration and developed site-specific controls and mitigation procedures. A recent update to the IEA protocol, now available in draft form (Majer et al., 2011), has also been incorporated into this plan.

The DOE and independent specialists retained by the Proponents have evaluated potential EGS induced seismicity and seismic hazards in the Project area and have analyzed the seismic risk. The specific objectives of the study were to: (1) evaluate the baseline seismic hazards in the Project Area including at La Pine, the closest community to the site; (2) estimate the potential increase in seismicity rate and the maximum magnitude of an earthquake induced by the hydroshearing in the injection well NWG 55-29; and (3) evaluate the increased seismic risk imposed by the hydroshearing activities.

In May of 2011, FS provided the Proponents with a list of 52 key assets within the NNVM, which includes various buildings, two bridges, a road, a dam, and three slope faces. The Proponents subsequently retained an independent engineering firm to conduct a structural engineering analysis to determine the vulnerability of these structures and features to potential induced seismicity.

The following discussion of potential increased seismic risk that could result from the proposed action (Alternative A) is based primarily on the report and the follow on addendum prepared by the Seismic Hazards Group at URS Corporation in November

[29] 1 g is the acceleration due to gravity. A PGA of 0.028 g is perceived as "light shaking" by USGS standards.

2010. These reports are included in Appendix F and G of the Induced Seismicity Mitigation Plan (ISMP) prepared by AltaRock[30], which is included as Appendix A to this document.

Maximum Magnitude Predictions

To develop site-specific, theoretical models of Maximum magnitude seismic events (M_{max}) for the Newberry EGS Demonstration, the Proponents commissioned the William Lettis & Associates division of Fugro Consultants (Fugro) in April, 2011. This assessment included additional analysis of LiDAR[31] data, updated physical and injection plan parameters, a model incorporating high heat flow at Newberry, and estimates of the probability of the different M_{max} levels. The Fugro study finds that the probability of the Newberry injection activity inducing an event with M > 3.0 is less than 1% over a 50-day period that would include injection and pressure dissipation (flow-back). At a 95% probability, the maximum induced event is predicted to be M < 2.2. The median (probability = 0.5) M_{max} for the most conservative assumptions is less than M = 1.0.[32] A summary of these calculated probabilities is shown below in Table 14.

Table 14: Calculated Probability of Even Occurrence

Event Magnitude	Event Probability Minimum	Maximum
>1	0.7%	40%
>2	0.1%	6%
>3	0.01%	0.8%
>4	0.002%	0.09%

[30] Figures and references noted in this section may be found in the report in Appendix F of the ISMP.

[31] Light Detection and Ranging, a method for high-precision topographic mapping.

[32] Mmax Assessment for the Newberry EGS Demonstration at the Davenport 55-29 Site, Fugro Consultants, Inc. May 2011.

Seismic Hazard

The URS study used the probabilistic seismic hazard analysis (PSHA) approach to assess the potential increased probability of induced seismicity from the Project to three locations: La Pine, Sunriver, and the area immediately above Well NWG 55-29. The study concluded there would be no increased earthquake or seismic hazard over existing baseline conditions as a result of the EGS stimulation:

> "..there is basically no contribution to the probabilistic hazard at La Pine, Sunriver, or at Well NWG 55-29 from EGS seismicity. The relatively low rate of M ≥ 4.0 induced earthquakes and associated low ground motions result in no differences in the hazard when EGS events are included." (URS 2010)

Ground Shaking

URS also estimated the level of ground shaking that might occur as a result of a potential induced seismic event from the Project. An M 3.5 scenario event was selected to represent an upper-range seismic event for the Project based on other similar EGS projects worldwide. This assumption has been approved by two independent technical teams contracted to review this report and the seismic mitigation plan by the DOE. Ground motion prediction models along with characterization of near-surface geology were used to estimate peak horizontal ground accelerations (PGA) values and create ground shaking maps. The maps show predicted levels of ground shaking around the Project site as characterized by PGA and the Modified Mercalli (MM) intensity scale. The MM intensity scale is used to quantify the effects of an earthquake on the impacted population, and the built and natural environment (Table 16). The relationship between PGA and MM intensity is shown in Table 15.

Table 15: Comparison of Quantitative and Qualitative Measures of Ground Shaking

MMI*	Peak Ground Acceleration (g)	Peak Ground Velocity (cm/s)	Perceived Shaking	Potential Damage
I	< 0.0017	<0.1	Not Felt	None
II-III	0.0017 - 0.014	0.1 - 1.1	Weak	None
IV	0.014 - 0.039	1.1 - 3.4	Light	None
V	0.039 - 0.092	3.4 - 8.1	Moderate	Very light
VI	0.092 - 0.18	8.1 - 16	Strong	Light
VII	0.18 - 0.34	16 - 31	Very Strong	Moderate
VIII	0.34-0.65	31-60	Severe	Moderate/Heavy
Continues to MMI XII, but not relevant for this discussion.				

* Modified Mercalli intensity scale, see discussion below

Table 16: First Eight of Twelve Levels of the Modified Mercalli Intensity Scale

I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
Continues to XII, but not relevant for this discussion.	

These ground shaking maps are shown below in Figure 29, Figure 30, Figure 31, and Figure 32.

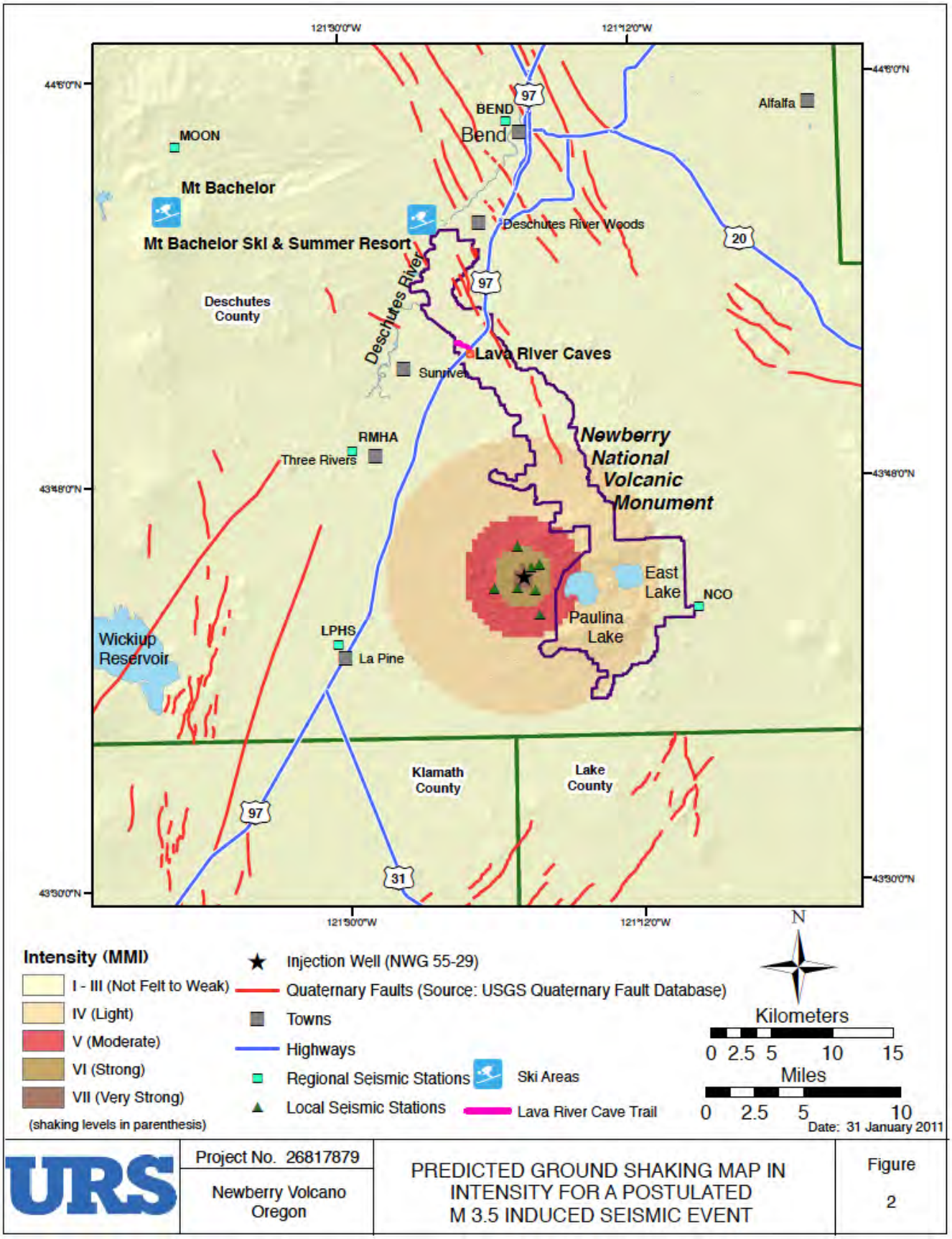

Figure 29: Predicted Ground Shaking Map in Intensity

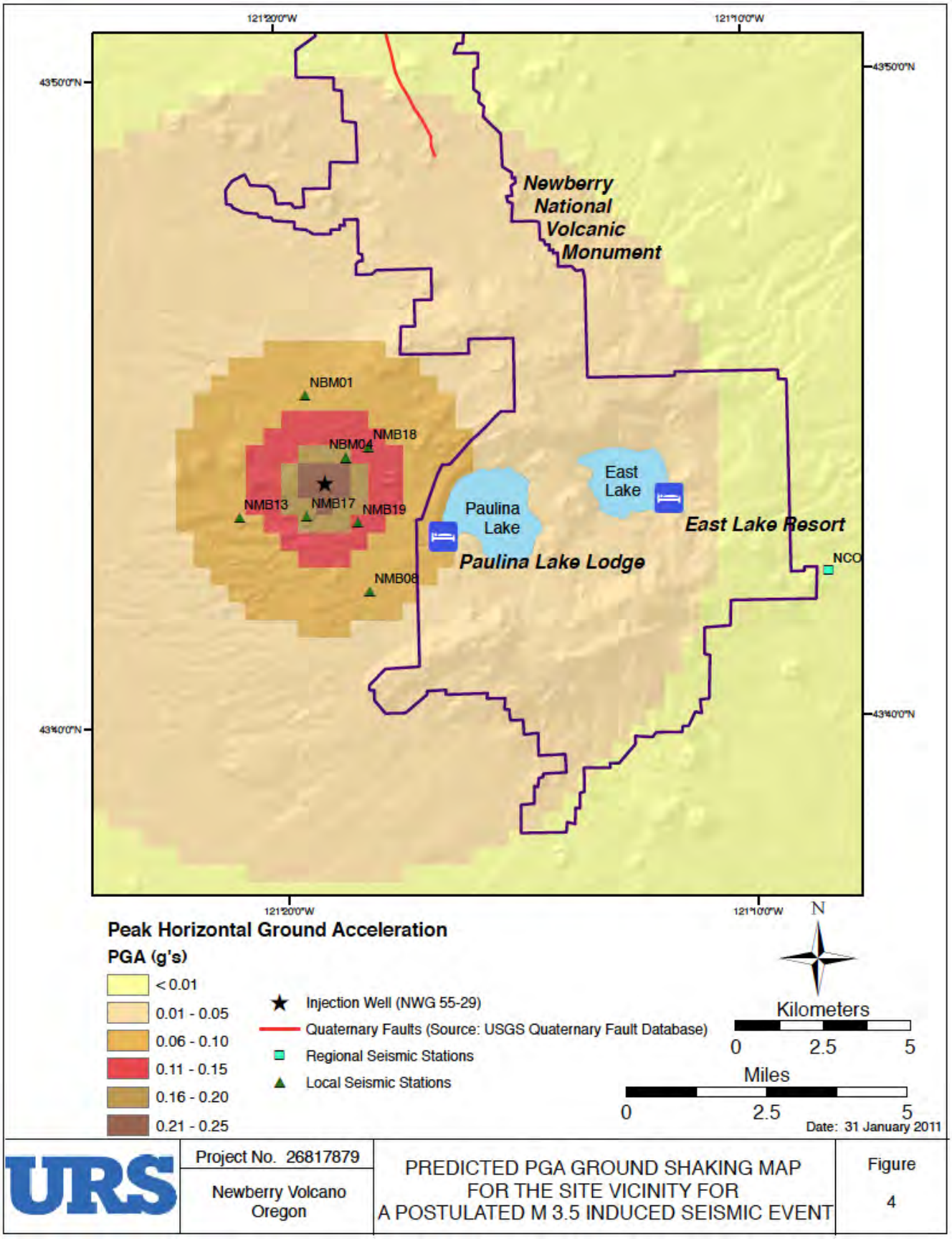

Figure 30: Predicted Ground Shaking Map in PGA

The URS study predicted ground shaking to be localized just around well NWG 55-29. The highest estimated PGA is 0.25 g at the well (MM intensity scale VII). Because the ground shaking is expected to be predominantly high frequency in content and short in duration, it was judged unlikely to be damaging. PGA values of .06 g and greater (moderate and stronger shaking) is confined to an area out to 5 km from the well. PGA of 0.01g and greater (light and stronger shaking) is felt out to distances of 12km. Residents west of Highway 97 between La Pine and Sunriver may feel weak shaking in an M 3.5 seismic event. If the postulated induced seismic event was smaller in magnitude, the PGA values would be smaller. For example, in an M 3.0 scenario event, the median PGA at the injection well would be 0.15 g.

Impact on Local Structures and Paulina Creek Bridge

There are only a few buildings located near the injection well (<5 km) where moderate ground shaking of MM V and greater could possibly occur and where there may be occupants in these buildings for an extended period of time (more than an hour). Those buildings are the Paulina Lake Lodge and associated cabins, the Paulina Lake Guard Station and the NNVM entrance station.

The engineering evaluation of buildings and bridges is included in Appendix H of the ISMP, a copy of which is attached as Appendix A of this document. Twelve representative structures were scored using the national standard document, FEMA 154, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*. For the twelve NNVM structures scored, the PGA resulting in a 10% probability of collapse was determined to be between 0.25 and 1.1 g. Further analysis indicates that in a "worst case" 0.10 g PGA that an M 3.5 seismic event could produce the collapse probability would be 1.2% or less for all NNVM structures. The engineering evaluation noted that the bridge is constructed "on fairly competent bedrock." It calculates the PGA limit for the bridge to be 0.28 g, similar to most susceptible buildings.

The engineering study also evaluated thresholds for cosmetic damage to buildings and recommended that the peak particle velocity be limited to 2 cm/s to minimize the potential for cosmetic damage to the buildings. This correlates to an approximate PGA of 0.025 g. As will be discussed in sections below, mitigation measures designed to slow induced seismicity will begin at a PGA of 0.014 g, well below the shaking level that might cause cosmetic damage, and an order of magnitude below the shaking level that would cause collapse of NNVM buildings.

The Paulina Lake buildings are located in the zone where PGAs are expected to be in the range of 0.06 to 0.10 g if the M 3.5 scenario event were to occur (Figure 31). It is expected that if these buildings were to be shaken in an M 3.5 induced seismic event with its expected short duration, structural damage would not be expected to occur assuming that these buildings are in reasonably good structural condition, although it is possible that some minor nonstructural damage might be incurred. This conclusion is consistent with observations of structural response at The Geysers. The Geysers is a geothermal field in northern California, where more than 50 years of geothermal production has resulted in more induced seismicity and seismic monitoring than anywhere in the world.

The study also looked at the bridges over the Paulina Creek dam (the bridge consists of both an older concrete bridge that also supports a newer steel bridge). The engineering study noted that the concrete bridge is in poor condition, with large horizontal cracks at the west face, while the newer steel bridge in good condition. The study concluded that the existing bridge capacity is well above the expected maximum level of acceleration expected at the bridge site. As a result, the trigger levels established in the ISMP are appropriate to protect against collapse of the bridge. Cosmetic damage is not expected at PGA ≤ 0.15 g, far higher than mitigation triggers. Because the concrete portion of the bridge is in poor condition, the study did recommend installing crack monitors on the bridge and the Proponents will implement this as a precautionary measure during the project.

Impact on Lava River Cave

Located well outside the area of light ground shaking and PGA values less than 0.01 g (Figure 29), visitors to the Lava River Cave will probably not detect any ground shaking in the occurrence of an M 3.5 seismic event. It is very unlikely that the cave itself will suffer even minor damage such as small roof falls if weak ground shaking were to occur. Observations by Bart Wills, Deschutes National Forest geologist, indicate that even when the cave underwent shaking from construction activities including compaction equipment during the expansion of Highway 97 which crossed directly over the cave, no damage was observed.

Impact on Paulina Creek Dam

Paulina Creek dam is located on the western side of Paulina Lake at the outlet to Paulina Creek. The dam was built around 1943 and is located 2.1 miles (3.4 km) from the injection well NWG 55-29 (Figure 31). The dam is described as a concrete wall 3 to 4 feet high and 12 to 14 inches thick, connected to a concrete bridge on the downstream side. Both concrete structures are "keyed into and bottomed in" bedrock.

Based on the M 3.5 scenario ground shaking map for peak horizontal ground acceleration (PGA) developed by Wong et al. (2011), the median PGA value expected at the dam site is in the range of 0.06 to 0.10 g. In a Memorandum dated 5 April 2011, Ivan Wong of URS concluded:

> "….it is highly unlikely that this low level of ground shaking will impact the dam... The high-frequency short-duration ground shaking from an EGS seismic event may result in some slight movement of pre-existing minor cracks but no significant deformation of the dam is expected."

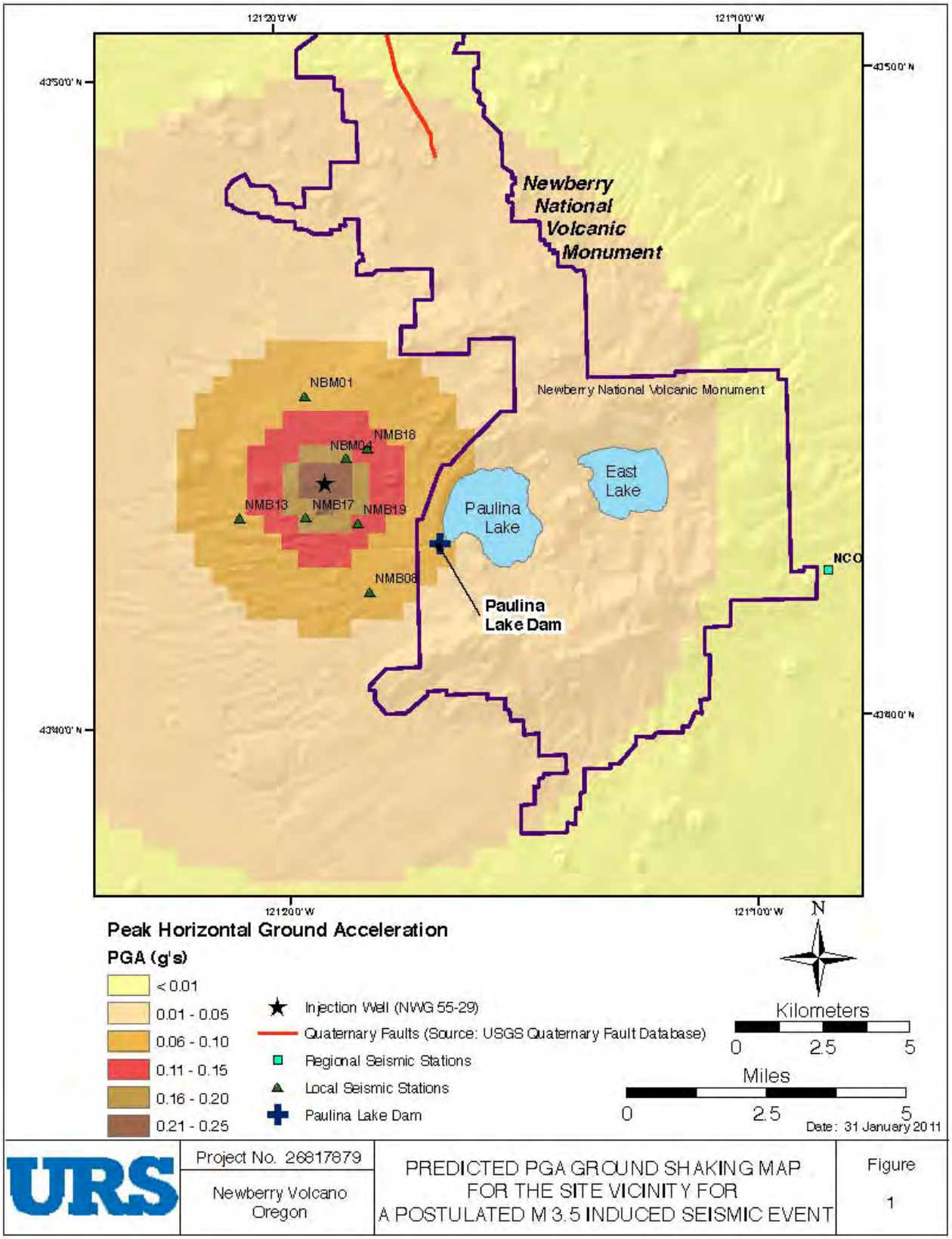

Figure 31: Predicted PGA Ground Shaking Map for Site Vicinity

As a follow up to the URS study, engineers from Treadwell & Rollo (T&R) conducted a geotechnical engineering evaluation of the dam and steep slopes, which is attached as Appendix I of the ISMP, attached as Appendix A of this document. According to the evaluation, no concrete dam is known to have failed as a result of earthquake induced ground motion, including a 372-foot high concrete arch dam that survived accelerations of 0.6 to 0.8 g caused by an M 6.6 earthquake. They concluded that the likelihood of damage is none for PGA values of 0.014 and 0.028g and only very light to light damage, which could consist of minor cracking for PGA values of 0.05 and 0.10g. Considering these low levels of acceleration and the previous performance of concrete dams, the probability of additional damage to the dam is low and the probability of failure of the dam is extremely remote.

They note that the dam already shows signs of cracking and evidence of crack monitoring, and conclude that additional cracking could occur at PGA up to 0.10 g, and that continued crack monitoring of the dam should be conducted as a mitigation measure. This mitigation is included in the ISMP, which would be implemented during the project.

Potential to Trigger Landslides

The T&R geotechnical engineering study also looked at the likelihood of landslides on the slopes of concern in the NNVM. This was evaluated by comparing the *maximum stable slope inclination* for the five rock types exposed to the slope inclinations measured from LiDAR imagery. The T&R geotechnical engineer concludes that "all geologic units have a low to very low risk of a deep seated landslide during static and minor earthquake loading with PGA's up to 0.1g." T&R provides further support for this conclusion from a survey by the USGS (Keefer, 1984) of landslides caused by earthquakes, which concluded that for a landslide to occur during an M 4 earthquake, the epicentral distance would need to be less than 0.2 km. At Newberry, the nearest slope of concern is more than 4 km away from the NWG 55-29 stimulation zone.

Potential to Trigger Avalanches

Ground shaking from earthquakes can trigger all forms of slope failure including avalanches. According to *Avalanche Safety for Skiers and Climbers* (Daffern, 1992), the major factors controlling avalanche risk are weather, snowfall, temperature, wind direction, snow pack conditions, slope angle, slope orientation, terrain, and vegetation. When the above conditions create an avalanche hazard, avalanches can be triggered naturally by additional snowfall, temperature changes, rock fall, ice fall, and occasionally by earthquakes (Wong et al., 2011), or artificially by skiers, snowmobiles, and controlled explosive work. Thus, an induced seismic event could potentially serve as a trigger to a snow avalanche, but the potential for an avalanche would be controlled by the natural risk factors unrelated to human activity such as snow pack conditions, weather, temperature, etc. If the avalanche hazards are high, winter visitors to the NNVM, such as backcountry skiers or snowmobilers, that venture onto slopes steeper than 25° will risk triggering an avalanche themselves (Daffern, 1992).

T&R discuss the potential for avalanches on the steeper slopes on the north shores of Paulina and East Lake specifically identified by FS as areas of concern. Avalanches can

occur on slopes as flat as 15 degrees and the likelihood increase for slopes with inclinations of 30 to 45 degrees. Most of the slopes in this area are generally less than 25 degrees except for isolated areas that are steeper. It appears that snow could accumulate to a sufficient thickness on these slopes where ground shaking could trigger an avalanche. However, heavily forested areas reduce the potential for avalanches to occur and the majority of the area is forested. If stimulation occurs in the winter, the Proponents would work with the FS to ensure that warning signs are posted at snow parks and other principal entrance points providing winter access to NNVM, warning that geothermal and other activities, when combined with weather and snow conditions, could trigger avalanches and to take extra precautions in avoiding steep slopes and avalanche prone areas.

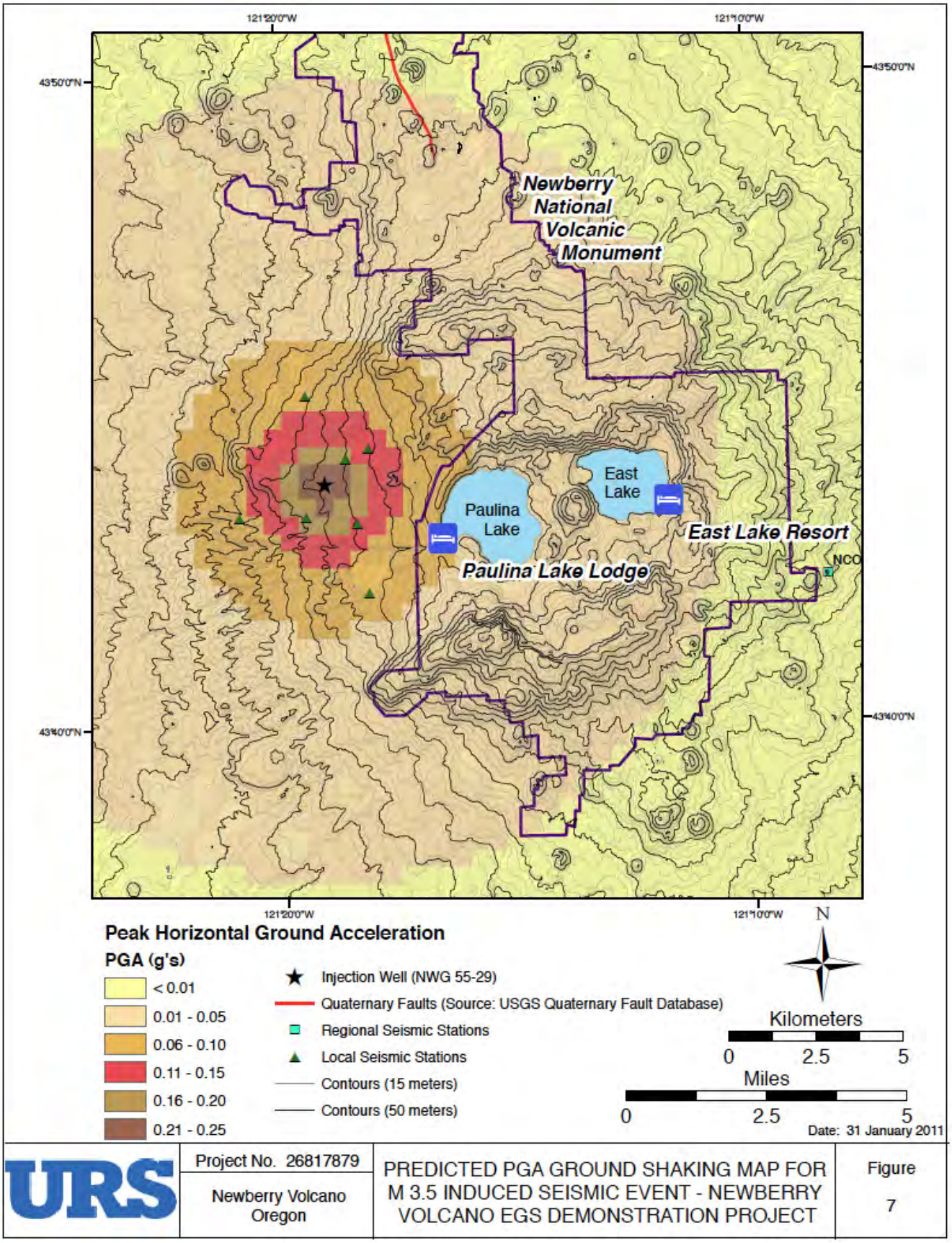

Figure 32: Predicted PGA Ground Shaking Map

SUMMARY

The combined conclusions of two different independent engineering analyses[33] indicate that:

- The probable upper-bound maximum magnitude of an induced seismic event at Newberry is M 3.5 to 4.0.
- The probability of a seismic event with a magnitude between M 3.0 and M 4.0 is less than 1%.
- There is no difference in seismic hazard between the natural seismicity and the hazard introduced by EGS induced seismicity.
- Mitigation measures outlined in detail in the ISMP (Appendix A) and Section 4.4, decrease flow at detection of events M 2.7 to 3.4 and then stop injection and flow the well to the surface to relieve pressure at detection of events equal to or higher than M 3.4.
- If an M 3.5 seismic event did occur, the potential for damage at the nearest structures within the NNVM would be light, corresponding to a MM Intensity level of VI.

ALTERNATIVE A, CUMULATIVE EFFECTS

Cumulative effects result from collective past, present, and reasonably foreseeable future actions, regardless of what agency or entity undertakes such actions.

The Proposed Action, Alternative A, has been evaluated for its potential effects to resources to be cumulative with other actions that are occurring or might occur on Newberry's west flank within the 32,000-acre area encompassing Davenport's geothermal leases and areas recognized as potentially having geothermal resources. Past, present, and reasonably foreseeable future projects from Section 4.2 have been considered.

WILDLIFE

Effects to wildlife under Alternative A were analyzed. The cumulative effects areas for the species further analyzed were either the Lower and Upper Paulina Creek 12th field subwatersheds or both (formerly 6th field). Lower Paulina Creek subwatershed is slightly northwest of Paulina Lake and extends west of the project to Highway 97. Upper Paulina Creek encompasses both Paulina and East Lake, extending to the north, east, south, and west of the two lakes. Below is a summary of the cumulative effects for the wildlife resource, while the specific subwatersheds used, including a more detailed analysis for each species are disclosed in the wildlife report and Biological Evaluation.

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[33] M_{max} Assessment for the Newberry EGS Demonstration at the Davenport 55-29 Site, Fugro Consultants, Inc. May 2011 and URS Study attached as Appendix E and F of the ISMP, a copy of which is included as Appendix A of this EA.

The analysis found that the three most influential activities to habitats within the last 100 years or so within the cumulative effect areas have been from: 1.) road development, 2.) timber management (both harvest and fuels reductions), and 3.) recreational use. Other past activities that have influenced habitats include: 1). wildfires, 2). two grazing allotments and 3). geothermal exploration.

Past road development has had the most influence on habitat fragmentation in the cumulative effects areas due to the amount of road density, impacting some species more so than others. Habitat fragmentation from roads has not only reduced the number of acres of habitat, it likely caused an impact to species that require larger blocks of continuous habitats and isolation and/or those species that are sensitive to human disturbance.

The earlier years of timber harvest (1920's – 1930's) has had a major influence on habitats (i.e. old growth ponderosa pine stands) due to the more extensive areas or acres of harvest than in more recent years (1970's – 1990's), therefore impacting those species dependent on old growth stands, those that require a more closed canopy stand and those that require more isolation. The more recent years of timber harvest included thinning and regeneration, but were not as extensive. Fuels treatments have impacted some wildlife species (i.e. decrease in shrub habitats or early to mid-seral trees), while benefitting other species, especially the areas that received prescribed burning.

Recreation has also had a major influence on acres of habitat and fragmentation due to developed trails and through dispersed public use. Recreational use occurs year-round and use is considered high in the area, but with most use occurring around the Paulina and East Lake areas, and camping, fishing, and hiking along Paulina Creek. This has caused some species of wildlife to change movement patterns, and either to move from the area or caused a temporary disturbance. Other recreational uses in these areas include snowmobiling, ATVs, hunting, sight-seeing, and/or joy riding.

It could be assumed that the future actions that may cumulatively affect the wildlife resources in relation to past and present actions are as follow: other geothermal activities, vegetation management, recreation use, and continued use of roads.

Other geothermal activities include clearing small areas for drilling and exploration. These activities contribute to noise disturbance and may cause habitat fragmentation and/or cause temporarily displacement of species due to the increase in human disturbance and noise.

The ongoing Ogden vegetation management project would influence habitat changes for some species, while improving habitat for others, but would contribute to increased traffic and noise disturbance for the life of the project.

In summary, when looking at the two subwatersheds, the existing conditions, and the scope of the proposed activities, such as the small area of vegetation to be removed (2/3 acre), low probability of occurrence for some species, no known nesting sites within proximity of drilling sites (¼ to ½ mile distance), and temporary duration of activity of

the project (180 days for drilling/project total 2 years), the EGS Project including the ongoing and foreseeable recreational uses and other geothermal developments would contribute to a slight increase in traffic and noise disturbance. This would slightly decrease the number of acres or areas of habitat without disturbance (fragmentation).

SCENIC RESOURCES

The EGS Project would be considered part of the cumulative effects for scenic resources in the area. Given the small scope, temporary duration, limited size, and minimal amount of new surface disturbance (2/3 acre) from the EGS Project, particularly when compared to the extensive and large scale (14,600 acres) Ogden Vegetation Management project in the vicinity, The EGS Project would have a minimal contribution to the overall degradation of the visual resource. Cumulative visual effects from timber sales and vegetation management projects have, and will continue to affect the area and be the major influence on the scenic character of the landscape.

GROUNDWATER

Potential impacts to groundwater resources from the EGS Project have been analyzed in detail and have been considered in context to other projects in the area that may use large amounts of water. The DOE looked at cumulative impacts from the Davenport TG Program[34]. A total of approximately 432,000 gallons of water would be pumped from local shallow groundwater wells to supply water for drilling the temperature gradient wells over the length of the project (estimate to be approximately 2 years). To date, Davenport has drilled the upper portions of 7 of those 12 wells. The groundwater wells have been permitted by the OWRD and groundwater mitigation credits have been purchased from the Deschutes Groundwater Mitigation Bank, operated by the Deschutes River Conservancy in accordance with the OWRD permit. Due to the goal of the Mitigation Bank of maintaining sustainable levels of water within the basin and the purchase of the credits there would be no net loss of water to the Deschutes river basin from this project

The proposed Ormat temperature gradient well drilling project, expected in spring of 2012 is anticipated to use approximately 216,000 gallons of water. Water for these wells would come from off-site municipal water sources in La Pine. All of these projects are temporary in use and are spread out over time.

The additional amount of water used by these two projects (648,000 gallons total over at least 3 years) is small in comparison to the water usage for the EGS Project (141.7 million gallons) and both projects will obtain water through local groundwater wells

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[34] Supplement to the cumulative impact analysis of "drilling, testing, and monitoring of up to 12 temperature gradient/passive seismic geothermal exploratory wells" DOE/EA-1758.

permitted by the OWRD with mitigation credits purchased from the Deschutes Groundwater Mitigation Bank, or from permitted municipal sources in La Pine.

Beyond direct and indirect effects for each specific project, cumulative effects would be minimal on water resources.

Geology and seismicity

A detailed evaluation has been conducted for seismic geologic effects, but other projects identified in the table of reasonably foreseeable future actions (Table 8) typically would not have a potential for similar effects. All projects would have impacts to soils due to site disturbance, but by applying Best Management Practices, reclaiming sites, and following LRMP guidance, cumulative effects to soils would be minimal.

Cumulative Effects Summary for Alternative A

As described above, under Alternative A, the EGS Project would utilize a very small amount of area, minimize new surface disturbance, be temporary in duration, and therefore not contribute to cumulative impacts to resources in the area.

4.4 Alternative B – Proposed Action with Closed Pressure Vessel and Air Cooled Condensers

As discussed in Chapter 2.4, Alternative B is identical to the proposed action described in Alternative A except for the long-term circulation test, which uses different equipment. This alternative was derived from public comments received during the scoping process expressing concerns over visual impact and water usage. In this alternative, closed, pressurized vessels will be used to separate steam at a higher pressure and temperature thereby reducing water lost through evaporation and reducing the visible steam plume, but requiring additional diesel engines and air-cooled heat exchangers to cool the separated liquid.

Because Alternative B differs from Alternative A only in the long-term circulation test equipment, many of the effects will be similar to those discussed for Alternative A.

Wildlife

Alternative B could have a slightly higher impact on some wildlife species due to the extra road traffic that would be required to supply equipment and diesel fuel for the air-cooled condensers. The impacts to wildlife would be similar for the other activities under both alternatives.

Scenic Resources

Alternative B differs from Alternative A in that it uses a different cooling system that would minimize the water vapor venting into the air, thereby requiring some additional facilities and equipment in order to capture and condense more of the steam. A pressurized liquid-vapor separator, air-cooled condensers, and related piping, valves and instrumentation would be added, and require additional diesel generators, fuel tanks and personnel to operate. This additional equipment would not be noticeably higher than that in Alternative A, but it would take up more room on the well pad and therefore be more visible from Paulina Peak. All of the additional equipment and

facilities would be located on existing well pad S-29, but the layout and type of equipment and facilities would need to be modified and more area of the pad would be utilized. There may also be a slight increase in vehicle traffic and associated road dust in order to supply diesel fuel, maintenance personnel and equipment, which would be abated as in Alternative A. Effects of these changes in Alternative B would not be discernibly different from those described in Alternative A.

Effects to scenic resources from Alternative B differ primarily because Alternative B may result in a reduced size and scale of the steam plume, making a plume less visible than in Alternative A from any viewing point. While it is difficult to quantify the difference in size and frequency of the steam plume between the two alternatives, one can compare the difference in water vapor being released to determine the relative difference in evaporative loss between the two. The use of air-cooled condensers in Alternative B would reduce evaporative losses by roughly 90% relative to Alternative A. This translates to a difference of approximately 67 million gallons over the 60-day test period. This reduction in evaporative loss would reduce the density, size and/or frequency of the steam plume, but would not eliminate it. In either alternative the plume would still be visible from a number of locations, but any impact on scenic resources would be temporary, localized and short term.

Groundwater Quantity

As discussed above, the use of air-cooled heat exchangers during the circulation test would reduce water use in Alternative B as compared to that in Alternative A. Table 17 shows the estimated water usage of Alternative B over a period of approximately 2 years.

Table 17: Maximum Water Use Estimate for All Major Activities in the Newberry EGS Demonstration, Alternative B

Activity	Estimated Water Usage Rate, gpm	Maximum Water Volume, gal	Maximum Water Volume, acre-ft	Duration, days
Single well stimulation[1]	800	24,192,000	74.2	21
Rig use during stimulation[2]	-	210,000	0.6	21
Drilling producer #1[3]		3,152,150	9.7	90
Drilling producer #2[3]		3,152,150	9.7	90
Connectivity test PW1[5]	455	4,583,439	14.1	7
Dual well stimulation PW1[4]	1600 (split between 2 wells)	11,520,000	35.4	5

Activity	Estimated Water Usage Rate, gpm	Maximum Water Volume, gal	Maximum Water Volume, acre-ft	Duration, days
Connectivity test PW2[5]	455	4,583,439	14.1	7
Dual well stimulation PW2[4]	1600 (split between 2 wells)	11,520,000	35.4	5
Circulation Test[6]	137	11,850,404	36.4	60
Total		74,763,582*	229.6	

* Total does not include the relatively small amount of water required to drill the 3 MSA boreholes at the beginning of the project (estimated to be up to 126,000 gals over a 6 week period)

[1]This uses Soultz GPK2 stimulation volumes and multiplies it by three to achieve our desired network size.

[2]Assumes rig is sitting idle during 21 days of stimulation operations and requires less than 10,000 gpd of water for standby operations.

[3]Davenport Power used 19.4 acre-ft when drilling both well 55-29 and 46-16. BLM assumes that usage would be similar during the proposed project.

[4]The dual well stimulation assumes pumping simultaneously at 800 gpm into two wells for a maximum total time of 5 days.

[5] The connectivity tests between the injection well and each individual producer are planned for a duration between 3 and 7 days. It is assumed that 16.3 to 37.6% of the flashing fluid will be lost to the atmosphere. Additionally, it is assumed that 2% of the injected volume is never recovered due to leak-off in the reservoir. The numbers above reflect a water usage rate of 455 gpm for a full 7 days with 37.6% of evaporative steam loss.

[6] The long-term circulation test is planned to last 30-60 days. It is assumed that 16.3%-37.6% of the production fluid will be lost to the atmosphere. Additionally, it is assumed that 2% of the injected volume is never recovered due to leak-off in the reservoir. The high end estimate is listed above and it represents 37.6% evaporation for a 60 day test.

The use of air-cooled condensers in Alternative B would reduce evaporative losses by roughly 90% relative to Alternative A. This translates to a difference of approximately 67 million gallons over a period of approximately two years. This represents approximately one-tenth of one percent (0.001) of the estimated annual recharge (73 billion gallons or 224,000 acre-feet) to the Deschutes Basin from the west flank of Newberry volcano.

Less water would be withdrawn from the aquifer beneath the project site under Alternative B, but correspondingly fewer mitigation credits would be purchased from the groundwater mitigation bank so there would be no net difference in water recharge to the Deschutes River Basin. There would be no difference in effects to other surface water bodies and aquifers in the project area compared to those discussed under Alternative A.

Groundwater Quality

There would be no difference in potential effects to Groundwater Quality from Alternative B in comparison to Alternative A.

Induced Seismicity

There would be no difference in potential effects with respect to induced seismicity from Alternative B in comparison to Alternative A.

Alternative B, Cumulative Effects

Cumulative effects result from collective past, present, and reasonably foreseeable future actions, regardless of what agency or entity undertakes such actions.

Alternative B has been evaluated for its potential effects to be cumulative with other actions that are occurring or might occur in the project area. Past, present, and reasonably foreseeable future projects from Section 4.2 have been considered.

Cumulative effects resulting from collective past, present, and reasonably foreseeable future actions for Alternative B are essentially the same as those identified above for Alternative A, the Proposed Action. Although the direct and indirect effects for Alternatives A and B may vary for certain specific resources, the cumulative effects of either alternative would be nearly identical. Alternative B could have a slightly higher impact on some wildlife species due to the extra road traffic that would be required to supply equipment and diesel fuel for the air-cooled condensers. Given the relatively limited scope, small scale, minimal surface area affected, and temporary duration of the EGS Project under either alternative, there would be little difference in cumulative effects between Alternative A and Alternative B, particularly when considering the other longer-term and extensive projects in the area. Therefore for cumulative effects for Alternative B, refer to the discussion provided above for cumulative effects for Alternative A.

4.5 Alternative C – No Action

Under The No Action Alternative, the EGS Demonstration Project would not take place and the existing well pad S-29 would remain as it is. When considered with other past, present, and reasonably foreseeable projects, it would not contribute to a significant cumulative effect on any resources within the project area. Therefore, the incremental contribution of the No Action Alternative is not cumulatively considerable.

CHAPTER 5. CONSULTATION AND COORDINATION

5.1 INTRODUCTION

This chapter identifies individuals, organizations, and agencies that contributed to the environmental analysis and participated in the preparation of the EA.

5.2 TRIBES, INDIVIDUALS, ORGANIZATIONS, AND AGENCIES CONSULTED

Prineville BLM and Deschutes National Forest are engaged in ongoing consultation with the Confederated Tribes of the Warm Springs Reservation, the Klamath Tribes, and the Burns Paiute Tribes on projects and issues involving uses of public or National Forest lands in central Oregon, including the EGS Project and other geothermal activities. The Klamath Tribe had an in-person consultation on this project by management of the Prineville District. No comments were submitted by any of the tribes during scoping.

During the analysis and preparation of the EA, additional information was obtained through contacts with individuals, organizations, and other agencies that contributed additional knowledge and expertise used during the NEPA process. A list of those consulted and their subject area are listed below.

NAME, ORGANIZATION, AGENCY	SUBJECT AREA
Robert Fujimoto, USFS Regional and National Offices	Geothermal
Kermit Witherbee, BLM National Office	Geothermal
Ivan Wong, URS Corporation	Seismic risk

5.3 LIST OF PREPARERS

This environmental assessment was prepared by a third-party contractor, PLS Environmental, LLC, under the direct supervision and control of BLM. Individuals who participated in the preparation of this document are listed below, along with the sections to which they provided assistance or prepared.

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