United States Department of Agriculture

Santa Fe National Forest Geothermal Leasing

Draft Environmental Impact Statement

Forest Service | Santa Fe National Forest | Coyote, Cuba, Espanola Jemez Ranger Districts | June 2016 MB-R3-10-23

Santa Fe National Forest
Draft Environmental Impact Statement
Sandoval and Rio Arriba Counties, New Mexico

Lead Agency:	**USDA Forest Service**
Cooperating Agencies:	**Bureau of Land Management** **National Park Service**
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Abstract: In accordance with the Energy Policy Act of 2005 (Public Law 109-58, August 8, 2005), Secretarial Order 3285A1 (amended February 22, 2010), and the Forest Service obligations under Section 225 of the Energy Policy Act, the Forest Service is required to facilitate the development and production of geothermal energy. This draft environmental impact statement (DEIS) documents the National Environmental Policy Act analysis for determining which lands would be available for geothermal leasing in the project area and under what stipulations. The DEIS analyzes four alternatives in detail: Alternative 1 (No Action), Alternative 2 (the Proposed Action), Alternative 3 (No Leasing), and Alternative 4 (Development Alternative). The proposed action would amend the 1987 Santa Fe National Forest Plan. This DEIS tiers to and incorporates by reference those elements of the 2008 Geothermal Programmatic Environmental Impact Statement that are appropriate for such use, such as resource impact analysis, stipulations, leasing procedures, and best management practices.

It is important that reviewers provide their comments at such times and in such a way that they are useful to the Forest Service's preparation of the EIS. Therefore, comments should be provided before the close of the comment period and should clearly state the reviewer's concerns and contentions. Submitting timely and specific comments can affect a reviewer's ability to participate in subsequent administrative review or judicial review. Comments received in response to this solicitation, including names and addresses of commenters, will be part of the public record for this proposed action. Comments submitted anonymously will be accepted and considered; however, anonymous comments will not provide the commenter with the opportunity to participate in subsequent administrative or judicial reviews.

Send written comments to:	**Geothermal EIS Project, Santa Fe National Forest** **11 Forest Lane** **Santa Fe, NM 87508**

Comments may also be sent via e-mail to comments-southwestern-santafe@fs.fed.us, or via facsimile to (505) 438-5390.

Comments must be received within 45 days of the Notice of Availability publication

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Summary

The Santa Fe National Forest (SFNF) proposes to identify lands in the project area administered by the Forest Service as closed to geothermal leasing under either nondiscretionary or discretionary authorities or open to geothermal leasing, subject to stipulations. The project area encompasses 194,910 acres in the Coyote, Cuba, Espanola, and Jemez Ranger Districts, of which 168,650 acres are National Forest System (NFS) lands.

This action is needed to allow the Forest Service to satisfy its statutory and policy mandates in responding to requests for the environmentally responsible development of energy resources and to respond to other policy directives calling for clean and renewable energy.

In 2008, the US Department of the Interior, Bureau of Land Management (BLM) recommended and the Assistant Secretary of Land and Minerals Management approved the Record of Decision (ROD) associated with the Programmatic Environmental Impact Statement (PEIS) for Geothermal Leasing in the Western United States. This led to a decision to amend BLM resource area management plans and provided certain National Forests with analysis to make decisions on existing lease applications. Decisions in the 2008 Geothermal ROD identified those lands that are legally open or closed to consideration for geothermal leasing on affected NFS lands; it provided stipulations, best management practices (BMPs), and procedures for geothermal leasing and development. The Forest Service has determined that additional site-specific environmental analysis is needed to supplement the 2008 Geothermal PEIS. This is so the Forest Service can make a decision about providing concurrence and consent to the BLM to lease lands in the SFNF for developing geothermal resources.

The Proposed Action

Under Alternative 2, the Proposed Action, the SFNF would implement discretionary and nondiscretionary leasing closures for geothermal resources. Approximately 32,000 acres would be closed (by law, regulations, or other authority) to geothermal leasing in the project area. Approximately 136,650 acres of NFS lands in the project area would be allocated as open to geothermal leasing. This would be subject to existing laws, regulations, formal orders, and stipulations attached to the lease form, and the terms and conditions of the standard lease form. Controlled surface use (CSU), no surface occupancy (NSO), and timing limitation (TL) stipulations would be implemented.

Public Involvement

The formal public scoping comment period, as required by the National Environmental Policy Act (NEPA; 40 Code of Federal Regulations [CFR], Subpart 1501.7), began on May 13, 2015, and ended on June 26, 2015. Scoping included the following:

- Notice of Intent (NOI) published in the *Federal Register* on May 13, 2015
- Media outreach, including press releases and a project website (http://www.fs.usda.gov/projects/santafe/landmanagement/projects)
- Scoping letter mailed to those on the project mailing list, including federal, state, and local agencies, Native American tribes, special interest groups, and landowners
- Public scoping meetings

Results of the public scoping are discussed in detail in the scoping report posted on the project website.

Alternatives Considered

Following the close of the public scoping period on June 26, 2015, the SFNF began developing alternatives. Based on public input, the interdisciplinary team's analysis of the current management situation and resource data and on the defined purpose and need for the project, the Forest Service developed four alternatives.

Under Alternative 1, the No Action Alternative, the SFNF would not make an availability determination for geothermal leasing on lands in the project area. It would continue processing geothermal lease applications and nominations but would evaluate them on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. This alternative does not meet the purpose and need.

Under Alternative 2, the proposed action, land in the project area administered by the Forest Service would be identified as being closed to geothermal leasing under either nondiscretionary or discretionary authorities or open to geothermal leasing with possible moderate constraints (TL and CSU stipulations) to major constraints (NSO stipulations).

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. The SFNF developed this alternative in response to comments received from the public and tribes during scoping. Although this alternative is contrary to program direction and mandates to make mineral and energy resources available, it is supportable, due to resource concerns and the level of protection needed. Alternative 3 may prevent geothermal development on private land in and adjoining the project area due to drainage of federal resource issues.

Under Alternative 4, land in the project area administered by the Forest Service would be closed to geothermal leasing under either non-discretionary or discretionary authorities, or would be open to geothermal leasing, with possible moderate constraints (TLs and CSU stipulations) to major constraints (NSO stipulations). There would be fewer areas identified as closed to geothermal leasing, and the stipulations would be less restrictive, compared with Alternative 2.

Decision to be Made

The SFNF supervisor is the Forest Service responsible official. Based on the environmental analysis and supporting documents in the project record, the forest supervisor will decide whether the proposed action should be implemented as proposed, modified by another action alternative, or not implemented at all. This decision is subject to the pre-decision administrative review process (objection process) under 36 CFR, Part 218, Subparts A and B.

Major Conclusions

Under Alternative 1, geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. The Jemez National Recreation Area would remain closed to geothermal leasing; however, no other geothermal-specific leasing closures or stipulations would be implemented to protect resource or resource uses in the project area outside of the Jemez National Recreation Area.

Potential indirect impacts from future geothermal leasing are as follows:

- Increased risk of seismic activity and ground subsidence
- Soil disturbance, compaction, and erosion
- Changes in groundwater flow paths, pressurization, and temperature
- Increased sediment and turbidity in surface water
- Vegetation removal
- Fish and wildlife habitat alteration and noise disturbance
- Increased short-term fugitive dust and vehicle emissions
- Disturbance to livestock and livestock grazing operations
- Reduced livestock grazing forage
- Disturbance to landscapes and locations associated with religious beliefs or cultural uses
- Temporary and long-term job creation

Alternative 1 would not meet the purpose and need of the project. This is because it would not identify reasonable and necessary conditions to protect surface and subsurface resources.

Indirect impacts under Alternative 2, the Proposed Action, would generally be similar to those under Alternative 1; however, discretionary closures and stipulations could reduce or mitigate impacts on some resource or resource uses. For example, soil disturbance, compaction, and erosion would occur, but soil stipulations would reduce erosion in areas with severe erosion hazards and steep slopes. Stipulations for streams and rivers would limit sediment transport and turbidity.

Fish and wildlife could be impacted through habitat alteration, removal, reduction, or fragmentation; however, implementation of stipulations would protect seasonally important wildlife habitat. Also, impacts would not lead to a substantial population change or trend toward federal listing for any species. Stipulations and closures for traditional cultural properties and Native American sacred sites, as identified though consultation, may reduce impacts, compared with Alternative 1; nevertheless, tribes consider the disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. The risk of seismic activity and ground subsidence would still occur under the proposed action.

Under Alternative 3, all Forest Service lands in the project area would be closed to geothermal leasing, and there would be no direct or indirect impacts.

Indirect Impacts under Alternative 4 would be similar to those described under Alternative 2, the Proposed Action. However, because fewer discretionary closures and stipulations would be implemented, the intensity or severity of impacts could be greater in certain areas. For example, soil erosion and runoff would be more likely to occur, and riparian areas would be more likely to experience disturbance or habitat alteration impacts.

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Appendix A. Management Areas and Prescriptions from Forest Plan
Appendix B. Stipulations and Closures by Alternative
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Acronym or Abbreviation	Full Term
$\mu g/m^3$	micrograms per cubic meter
AADT	annual average daily traffic
ACEC	Area of Critical Environmental Concern
AMZ	aquatic management zone
AQRV	air quality related value
AUM	animal unit month
BLM	United States Department of the Interior, Bureau of Land Management
BLS	Bureau of Labor Statistics
BMP	best management practice
°C	degree Celsius
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CWA	Clean Water Act
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COA	condition of approval
CRMP	Cultural Resource Management Plan
CSU	controlled surface use
CWE	cumulative watershed effects
dBA	a-weighted decibel
DOE	United States Department of Energy
EIA	Energy Information Administration
EIS	environmental impact statement
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act of 1973
°F	degree Fahrenheit
FLPMA	Federal Land Policy and Management Act of 1976
Forest Plan	Santa Fe National Forest Plan
GHG	greenhouse gas
GIS	geographic information system
IPCC	Intergovernmental Panel on Climate Change
IRA	inventoried roadless area
JNRA	Jemez National Recreation Area
KGRA	known geothermal resource area
LANL	Los Alamos National Laboratory
MBTA	Migratory Bird Treaty Act
MIS	management indicator species
MOU	memorandum of understanding

MSO	Mexican spotted owl
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFS	National Forest System
NHD	National Hydrography Dataset
NHPA	National Historic Preservation Act
NMDGF	New Mexico Department of Game and Fish
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NMWQCC	New Mexico Water Quality Control Commission
NOI	notice of intent
NORM	naturally occurring radioactive materials
NPS	United States Department of the Interior, National Park Service
NRA	National Recreation Area
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSO	no surface occupancy
PAC	protected activity center
PEIS	programmatic environmental impact statement
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
ppb	parts per billion
ppm	parts per million
PRRAS	Paleontological Resources Rapid Assessment System
PSD	prevention of significant deterioration
RFDS	reasonably foreseeable development scenario
RGCT	Rio Grande cutthroat trout
ROD	record of decision
ROI	region of interest
ROS	recreation opportunity spectrum
ROW	right-of-way
SHPO	State Historic Preservation Office
SFNF	Santa Fe National Forest
TL	timing limitation
TMDL	Total Maximum Daily Load
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VCNP	Valles Caldera National Preserve
WEG	wind erodibility group

Chapter 1. Purpose of and Need for Action

1.1 Introduction

In 2008, the US Department of the Interior, Bureau of Land Management (BLM) recommended and the Assistant Secretary of Land and Minerals Management approved the Record of Decision (ROD) associated with the Programmatic Environmental Impact Statement (PEIS) for Geothermal Leasing in the Western United States. This led to a decision to amend BLM resource area management plans and provided analysis to allow certain National Forests to make decisions on existing lease applications.

Decisions in the 2008 Geothermal ROD identified those lands that are legally open or closed to consideration for geothermal leasing on affected National Forest System (NFS) lands; it provided stipulations, best management practices (BMPs), and procedures for geothermal leasing and development. The Forest Service has determined that additional site-specific environmental analysis is needed to supplement the 2008 Geothermal PEIS. This is so the Forest Service can make a decision about providing concurrence and consent to the BLM to lease lands in the Santa Fe National Forest (SFNF) for developing geothermal resources. The regulations governing the relationship between the BLM and Forest Service (43 CFR, Subpart 3201.10[a][2]) use the term “concurrence.” Throughout this document “concurrence” and “consent” are used interchangeably.

The 2008 Geothermal PEIS and ROD was prepared in accordance with the planning requirements of the Federal Land Policy and Management Act of 1976, as amended (FLPMA) and its implementing regulations at 43 CFR, Part 1600, as well as with the National Environmental Policy Act (NEPA) and its implementing regulations at 40 CFR, Parts 1500 through 1508.

The Forest Service’s proposed action is to determine which lands in the SFNF on the Coyote, Cuba, Espanola, and Jemez Ranger Districts would be available for geothermal leasing and under what stipulations. As appropriate, this proposed action would amend the 1987 Santa Fe National Forest Plan, or the results of this environmental impact statement (EIS) would be incorporated into the revised Forest Plan.

The Forest Service has prepared this EIS in compliance with NEPA and other relevant federal and state laws and regulations. This EIS identities the direct, indirect, and cumulative environmental impacts that would result from the proposed action and alternatives.

Additional documentation, including more detailed analyses of project area resources, may be found in the project planning record located at the SFNF.

This chapter details the purpose and need for the proposed action, the action’s objective, the planning and decision areas. It also provides the following:

- Provides a brief background on geothermal resources and the leasing and development process
- Details the relationship of the proposed action to existing policies and plans
- Outlines the scope of the analysis for the proposed action, the decisions to be made after analysis, and issues to be addressed based on internal and external scoping

Secretarial Order 3285A1, amended February 22, 2010, establishes the development of environmentally responsible renewable energy as a United States Department of Interior priority. The US Department of Agriculture, Forest Service (Forest Service) has obligations under Section 225 of the Energy Policy Act to facilitate the development and production of geothermal energy.

The State of New Mexico, through the Renewable Portfolio Standard, has mandated that investor-owned utilities procure renewable energy and renewable energy certificates from New Mexico renewable generation facilities. In 2007 legislative changes to the Renewable Energy Act (SB418, signed by Governor Bill Richardson) mandated that investor-owned utilities must have in their portfolio as a percentage of total retail sales to New Mexico customers, renewable energy of no less than 15 percent by 2015 and 20 percent by 2020.

Geothermal resources, along with oil and gas, fall under the Forest Service Leasable Minerals Program. The Geothermal Steam Act of 1970 gives the Secretary of the Interior authority to issue geothermal leases on NFS lands and regulates subsurface geothermal activities through the BLM (BLM; 30 United States Code [USC] 1002, Section 3).

In response to lease nominations and inquiries from industry, the BLM has requested the concurrence of the Forest Service to lease NFS lands in the SFNF for future geothermal exploration, development, and production (see **Section 1.5**, Leasing and Development Process of Geothermal Resources on NFS Lands, for more information about the leasing process). The BLM may only lease nominated NFS lands with Forest Service consent (43 CFR, Part 3201.10[a][2]). Before providing concurrence to the BLM for leasing, the Forest Service is responsible for conducting a NEPA analysis for leasing, for developing appropriate terms and conditions under which leases may be issued, and for ensuring decisions are consistent with the SFNF Plan.

1.2 Purpose and Need for Action

The purpose of the action is to refine the analysis available in the PEIS in order to determine if certain lands in the SFNF may be made available for geothermal leasing and, if so, to provide consent to leasing of lands and to identify reasonable and necessary conditions to protect resources.

The need for the action is twofold: (1) to allow the Forest Service to satisfy its respective statutory and policy mandates in responding to requests for the environmentally responsible development of energy resources and (2) to respond to other policy directives calling for clean and renewable energy.

Specifically, the United States Geological Survey (USGS) has identified approximately 194,000 acres of SFNF lands with significant geothermal potential; the BLM has received expressions of interest in leasing approximately 46,000 acres of this land for geothermal energy production. This action is needed because the SFNF Plan, as amended (Forest Service 1987) does not allocate areas as open or closed to geothermal leasing, does not have adequate stipulations or BMPs to apply to geothermal leases to protect sensitive resources, and does not assess the reasonably foreseeable development scenario (RFDS), as required in the 2008 PEIS.

While the current expressed interest in geothermal leasing does not constitute all 194,000 acres, the entire area plus an additional approximately 900 acres for power transmission will be considered in the analysis in the event that the SFNF needs to address future interest. By incorporating all lands identified as containing significant geothermal potential under one EIS, the SFNF can address future nominations and applications and provide consent or non-consent in a timely manner.

1.3 Description of the Project Area and Decision Area

The project area encompasses approximately 194,910 acres, as follows:

- Approximately 26,212 acres are privately owned
- Approximately 48 acres are owned by state or other government entities
- Approximately 168,650 acres are NFS lands (lands on the Coyote, Cuba, Espanola, and Jemez Ranger Districts of the SFNF [**Figure 1-1**, Geothermal Leasing Project Surface Administration]). These lands comprise the decision area for the project; non-federal lands are not included in this decision.

The project area is in Sandoval and Rio Arriba Counties, New Mexico. The SFNF defined spatial boundaries for five units in the project area, for the purpose of future planning and characterizing existing conditions. These units, on lands managed by the SFNF, are listed below:

- Lease Interest Unit (39,200 acres)
- North Unit (48,200 acres)
- Middle Unit (10,800 acres)
- Jemez National Recreation Area (JNRA) Unit (39,200 acres)
- South Unit (34,400 acres)

1.4 Background for Geothermal Resources

As described in the 2008 PEIS, the term geothermal comes from the Greek words *gé*, meaning earth, and *thermé*, meaning heat, as geothermal energy is derived from the natural heat of the earth. Geothermal resources are typically underground reservoirs of hot water or steam created by heat from the earth, but geothermal resources also include subsurface areas of dry hot rock. In cases where the reservoir is dry hot rock, the energy is captured by injecting cool water from the surface, which is then heated by the hot rock and extracted as fluid or steam.

Geothermal steam and hot water can naturally reach the earth's surface in the form of hot springs, geysers, mud pots, or steam vents. Geothermal reservoirs of hot water are also found at various depths beneath the Earth's surface. In the United States, geothermal resources are most ubiquitous in the western states, Alaska, and Hawaii (Tester et al. 2006; NREL 2015a).

Geothermal resources can be accessed by wells and used to provide heat directly. This is called the direct use of geothermal energy. The heat energy can also be used to commercially generate electricity, a process called indirect use. As shown in **Figure 1-2**, Uses of Geothermal Energy, there are a wide range of uses for geothermal resources.

1.4.1 Direct Use

Humans have been using geothermal resources in the form of hot springs for thousands of years, and direct heat use is one of the most versatile forms of geothermal energy use (Dickson and Fanelli 2003, p. 16). Today, geothermal reservoirs with waters of 68 degrees Fahrenheit (ºF) to 302ºF (20 degrees Celsius [ºC] to 150ºC) temperature water provide numerous opportunities for direct use. Direct use means using geothermal resources for commercial, residential, agricultural,

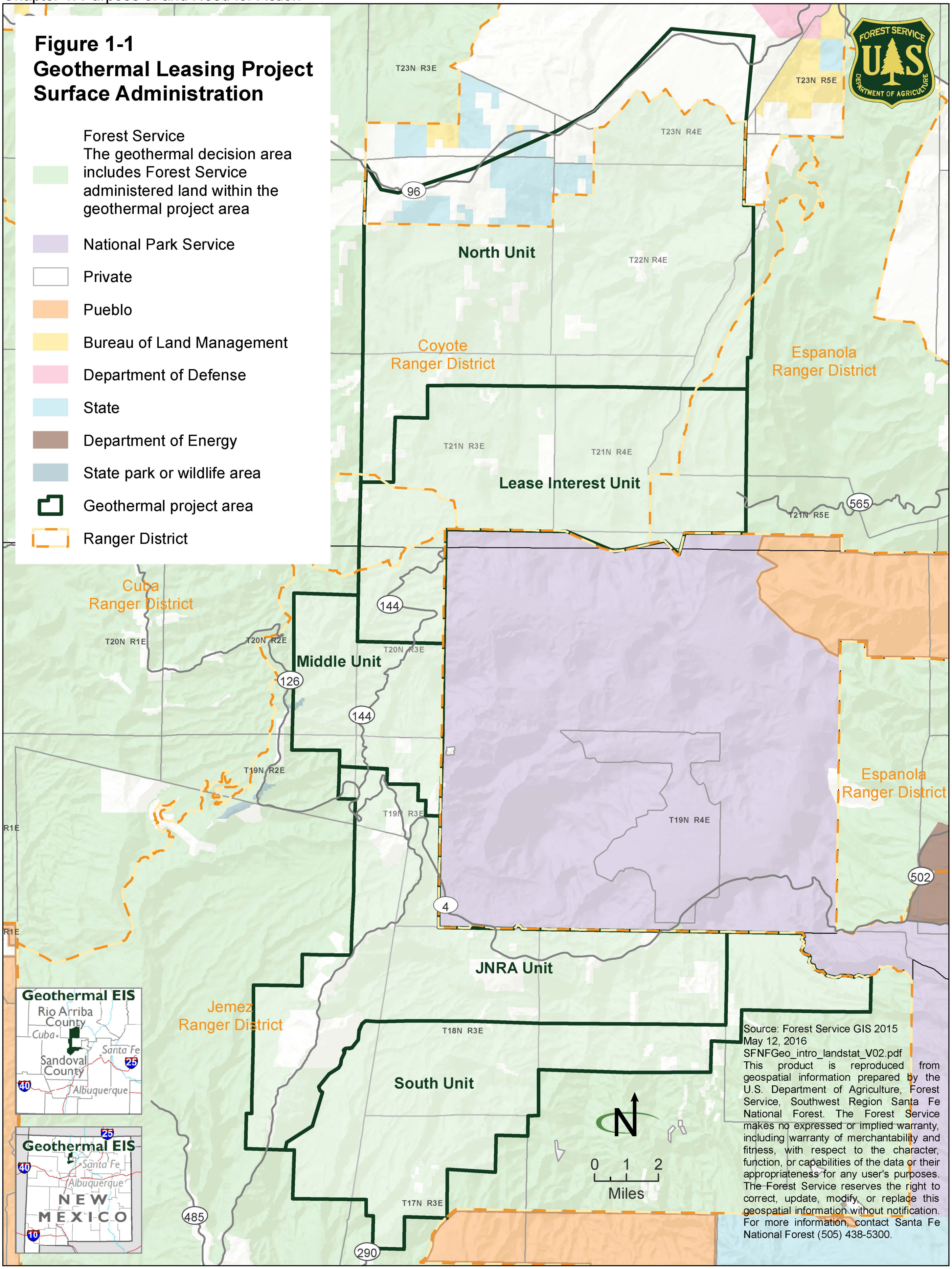

Figure 1-1
Geothermal Leasing Project
Surface Administration
Forest Service
The geothermal decision area includes Forest Service administered land within the geothermal project area
National Park Service
Private
Pueblo
Bureau of Land Management
Department of Defense
State
Department of Energy
State park or wildlife area
Geothermal project area
Ranger District
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
T23N R3E
T23N R4E
T23N R5E
T22N R4E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T17N R3E
96
144
126
4
565
502
485
290
Geothermal EIS
Rio Arriba County
Cuba
Sandoval County
Santa Fe
Albuquerque
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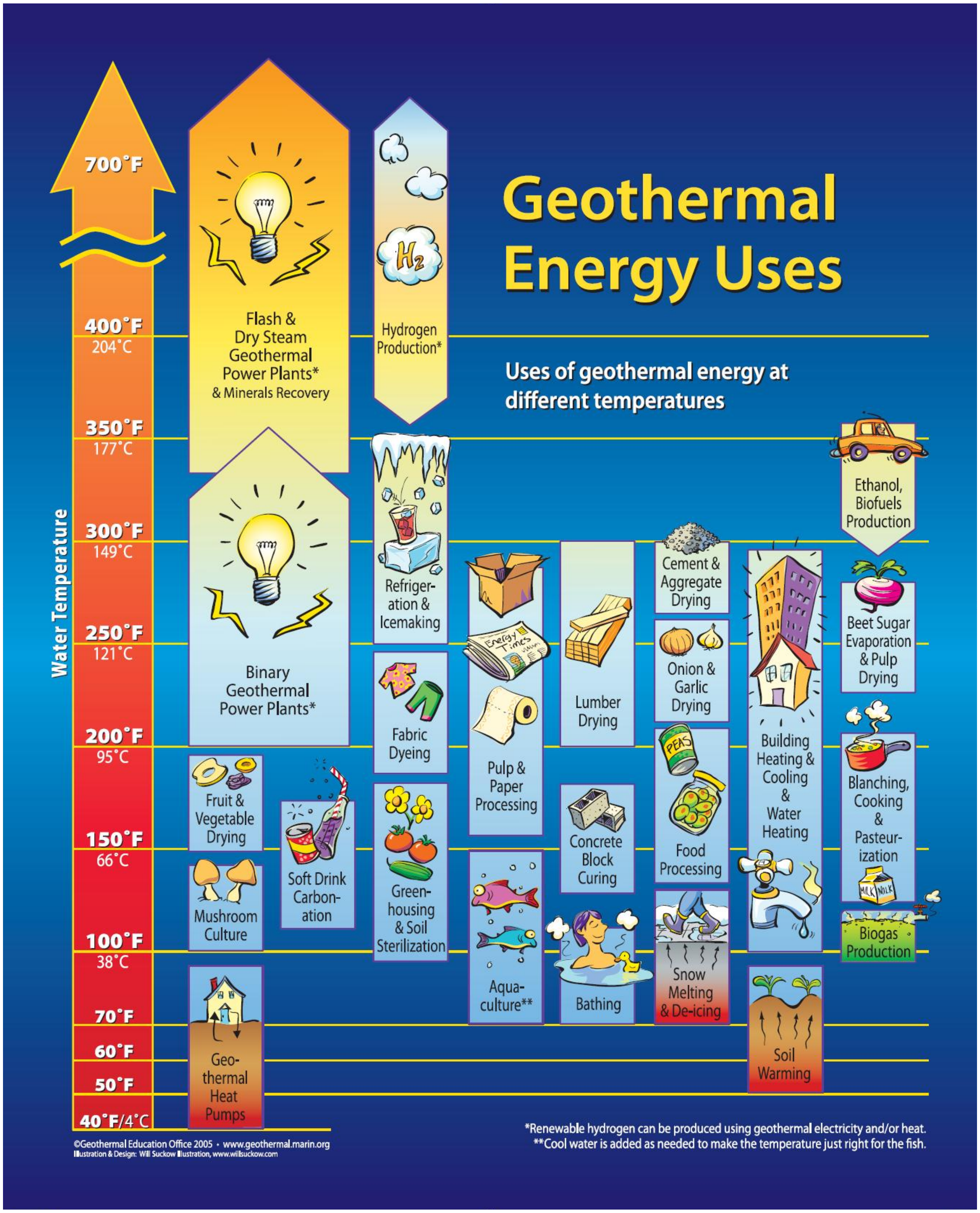

Figure 1-2. Uses of Geothermal Energy (from 2008 PEIS; BLM and Forest Service 2008)

or public facilities or for energy needs other than the commercial production of electricity (43 CFR, Part 3200.1). The direct use of geothermal energy includes heating pools and spas, greenhouses and aquaculture facilities, and melting snow, and drying agricultural products. Direct use also has industrial applications and can be used for ground-source heat pumps (Lund and Boyd 2015).

Direct uses in the United States have been growing at about 7 percent per year. The largest applications of direct heat uses in the United States are ground-source heat pumps, accounting for 88 percent of the annual energy use for all geothermal direct uses (Lund and Boyd 2015).

1.4.2 Commercial Electrical Generation

Commercial electrical generation from geothermal resources is also called indirect use. Electrical generation uses geothermally heated fluid to turn a turbine connected to a generator. As discussed below, the fluid may be the naturally occurring steam or water in the geothermal reservoir or another fluid that has the geothermal heat transferred through a heat exchange system.

Geothermal energy has been a small but consistent source of electricity in the United States since 1971, providing 0.4 percent of total US generation in 2013 (EIA 2015a). As of 2013, there were 64 operating conventional geothermal power plants in the United States, accounting for nearly 2,700 megawatts (MW) of total capacity (EIA 2015a).

Geothermal power plants can be small (generating 300 kilowatts), medium (generating 10 to 50 MW), and large (generating 50 MW and higher; Nemzer et al. 2007). Generation capacity is guided by the number of turbines in a plant. To extract thermal energy economically, one must drill to depths where temperatures are sufficiently high to justify investment in the heat-mining project. For commercial electricity generation, this generally means drilling to rock temperatures in excess of 300ºF (149ºC) (Tester et al. 2006). However, new technologies have proven that lower-temperature water (below 300ºF [149ºC]) can also be used for electrical generation (Aneke et al. 2011; BLM and Forest Service 2008; DOE 2015).

The following three types of geothermal power plant systems are commonly used to generate electricity, depending on temperature, depth, and quality of the water and steam in the area (NREL 2015b):

- Flash steam
- Binary-cycle
- Dry stream power plants

These plants can also be hybridized by including elements of the different technologies at a single location. In all three methods the remaining geothermal fluid is injected back into the ground to replenish the reservoir and recycle the residual hot water. Geothermal power plant systems are described in detail in the 2008 Geothermal PEIS (BLM and Forest Service 2008).

1.5 Leasing and Development Process of Geothermal Resources on National Forest System Lands

1.5.1 Federal Geothermal Leasing Laws and Regulations

A federal geothermal lease grants "the exclusive right to drill for, extract, produce, remove, utilize, sell, and dispose of all the geothermal resources" in the lands described within the lease form. According to 43 CFR, Part 3200.1, geothermal steam and associated geothermal resources are defined as follows:

- All products of geothermal processes, including indigenous steam, hot water, and brines
- Steam and other gases, hot water, and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations
- Other associated energy found in geothermal formations
- Any byproducts

The BLM has the delegated authority to issue geothermal leases on federal lands. It is the policy of the federal government, consistent with Section 2 of the Mining and Mineral Policy Act of 1970 and Sections 102(a)(7), (8), and (12) of the FLPMA (43 USC, Section 1701 et seq.), to encourage the development of mineral resources, including geothermal resources, on federal lands. The Geothermal Steam Act of 1970 (30 USC, Section 1001 et seq.), which was amended and supplemented by the Energy Policy Act of 2005, provides statutory guidance for geothermal leasing by the BLM. Federal geothermal development regulations (43 CFR, Parts 3000, 3200, and 3280—Geothermal Resource Leasing and Geothermal Resources Unit Agreements) were made effective June 1, 2007 (72 *Federal Register* 24358, May 2, 2007), as a result of a directive provided in the Energy Policy Act of 2005. These statutes and regulations delineate lands that are available and unavailable for leasing.

1.5.2 Leasing and Development Process, Rights, and Limitations

The BLM grants access to geothermal resources through a formalized leasing process based on the end use. For direct uses, an applicant can apply noncompetitively for a lease; for indirect use, such as commercial electrical generation, the BLM awards leases through a competitive bidding process. Historically, certain lands were designated as known geothermal resource areas (KGRAs). All lands designated within KGRAs were leased through a competitive bidding process. Before the passage of the Energy Policy Act of 2005, lands outside of known geothermal resource areas could be leased noncompetitively. Section 222 of the Energy Policy Act of 2005 modified the Geothermal Steam Act of 1970 to allow only competitive lease sales for all federal geothermal resources and their associated lands; however, there were the following exceptions:

- Parcels of land that did not receive bids in a competitive sale
- Lands available exclusively for direct use
- Lands with a mining claim and a current approved plan of operations
- Lands for which a lease application was pending on August 8, 2005, if the applicant so chooses

Lease areas are nominated by the public for a lease sale, whereas the public is defined as follows:

- A US citizen at least 18 years old
- An association of US citizens, including a partnership
- A corporation organized under the laws of the United States
- Any state or the District of Columbia
- A domestic government unit

When the BLM receives a nomination, it is adjudicated and configured into lease parcels by the respective BLM state office. Lease parcels are then forwarded to the appropriate Forest Service office, where the appropriate environmental analysis and review is conducted. Environmental analysis and review yields a consent or non-consent decision for geothermal leasing. With the Forest Service's consent, and once lease parcels are configured, the BLM is responsible for conducting geothermal lease sales and issuing competitive and noncompetitive leases.

The BLM holds a competitive lease sale at least once every two years for lands available for leasing in a state that has nominations pending. Although the BLM cannot issue a lease without the consent of the Forest Service, it can add any additional terms, conditions, or stipulations that it deems necessary and appropriate. Also, the BLM must make an independent decision on whether to issue the lease after reviewing the decision and documentation presented by the Forest Service.

The four stages of geothermal resource development within a lease area are exploration, drilling operations, utilization, and reclamation and abandonment. Each stage requires a permit from the BLM and is described in detail in Chapter 2 of the 2008 Geothermal PEIS (BLM and Forest Service 2008). Leasing geothermal resources from the BLM vests with the lessee a nonexclusive right to future exploration (non-production) and an exclusive right to produce and use the geothermal resources in the lease area. This is subject to existing laws, regulations, and formal orders. The lease is also subject to the terms, conditions, and stipulations in or attached to the lease form or included as conditions of approval to permits.

Lease issuance alone does not authorize any ground-disturbing activities to explore for or develop geothermal resources without site-specific approval for the intended operation. Such approval could include additional environmental reviews and permits. Also at each stage, the BLM can issue site-specific conditions of approval (COAs) to protect resource values. For both exploration and production or utilization operations on leased lands, the BLM determines if the permit application should be approved. It coordinates NEPA review with the Forest Service, which may propose permit conditions of approval involving surface issues. The level of environmental analysis to be required under NEPA for subsequent individual exploration, development, and production permits is determined at the BLM field office and Forest Service unit level.

A lease is issued for a primary term of 10 years and may be extended for two five-year periods. The BLM will extend the primary term for five years under one of the following circumstances:

- The lessee has satisfied the minimum work requirement or made a payment to the BLM equivalent to the required work; in such a case, the total of the payment and the value of the work performed must equal $40 per acre (43 CFR, Parts 3207.10 and 3207.11).
- The lessee submits documentation to the BLM that geothermal resources are produced or used in commercial quantities (43 CFR, Parts 3207.10 and 3207.11).

Once commercial production is established, the lease may receive a production extension of up to 35 years and a renewal period of up to 55 years. The lease must continue to produce to remain in effect. The BLM may grant a suspension of operations and production on a lease when justified by the operator (43 CFR, Part 3207). A diagram outlining the leasing and development process, including what stages provide opportunities for public involvement, is shown in **Figure 1-3**, Geothermal Leasing and Development Process.

Geothermal exploration and production on federal land conducted through leases is subject to lease terms and stipulations and must also comply with all applicable federal and state laws pertaining to various considerations for tribal interests, sanitation, air quality, solid waste, scenic values, roads, water quality, wildlife, safety, cultural resources, and reclamation.

New Mexico classifies geothermal resources as mineral if the fluid produced has a temperature greater than 250°F and as water if the fluid produced has a temperature less than or equal to 250°F. If the fluid produced is considered mineral, the resource is under the primary jurisdiction of the New Mexico Department of Energy, Minerals, and Natural Resources. This agency coordinates with the US Environmental Protection Agency (EPA), Region 6, which has authority over wastewater discharge to surface waters in the state. Both of these agencies, in addition to the New Mexico Environment Department (NMED), have regulatory authority over geothermal discharge permits.

Geothermal fluid less than 250°F is considered water and is under the primary responsibility of the New Mexico Office of the State Engineer (NMOSE) for drilling and permitting. The EPA also has authority over wastewater discharge to surface waters in the state for fluids less than 250°F. State permitting is beyond the scope of this project.

1.6 New Mexico Geothermal Potential

At the broad level, the 2008 PEIS (BLM and Forest Service 2008) estimated the potential for geothermal energy. However, since that time, changes in technology and more specific studies were conducted so that these areas may be more closely designated. In order to assess where geothermal development could occur, the SFNF conducted a detailed review of literature pertaining to existing geothermal potential studies on lands covering the SFNF.

The US Geological Survey (USGS 2010) reviewed geographic information system (GIS) data for lands with highly favorable geothermal development potential. This study analyzed 12 models that correlate different geological and geophysical factors to the known presence of moderate (90 to 150°C) to high (greater than 150°C) temperature geothermal systems (Williams and DeAngelo 2008; Williams et al. 2008; Williams et al. 2009). The SFNF also evaluated the location of KGRAs that the USGS identified as containing geothermal resources (Forest Service 1977). Although KGRAs no longer guide the geothermal leasing process, they do show areas of potential geothermal resources. Additionally, the SFNF evaluated data published in a US Department of Energy (DOE) commissioned study: Opportunities for Near-Term Geothermal Development on Public Lands in the Western United States (DOE and BLM 2003). Based on the information contained in these studies, the SFNF identified lands most likely to receive geothermal lease nominations and applications. This area was defined as the project area for the EIS.

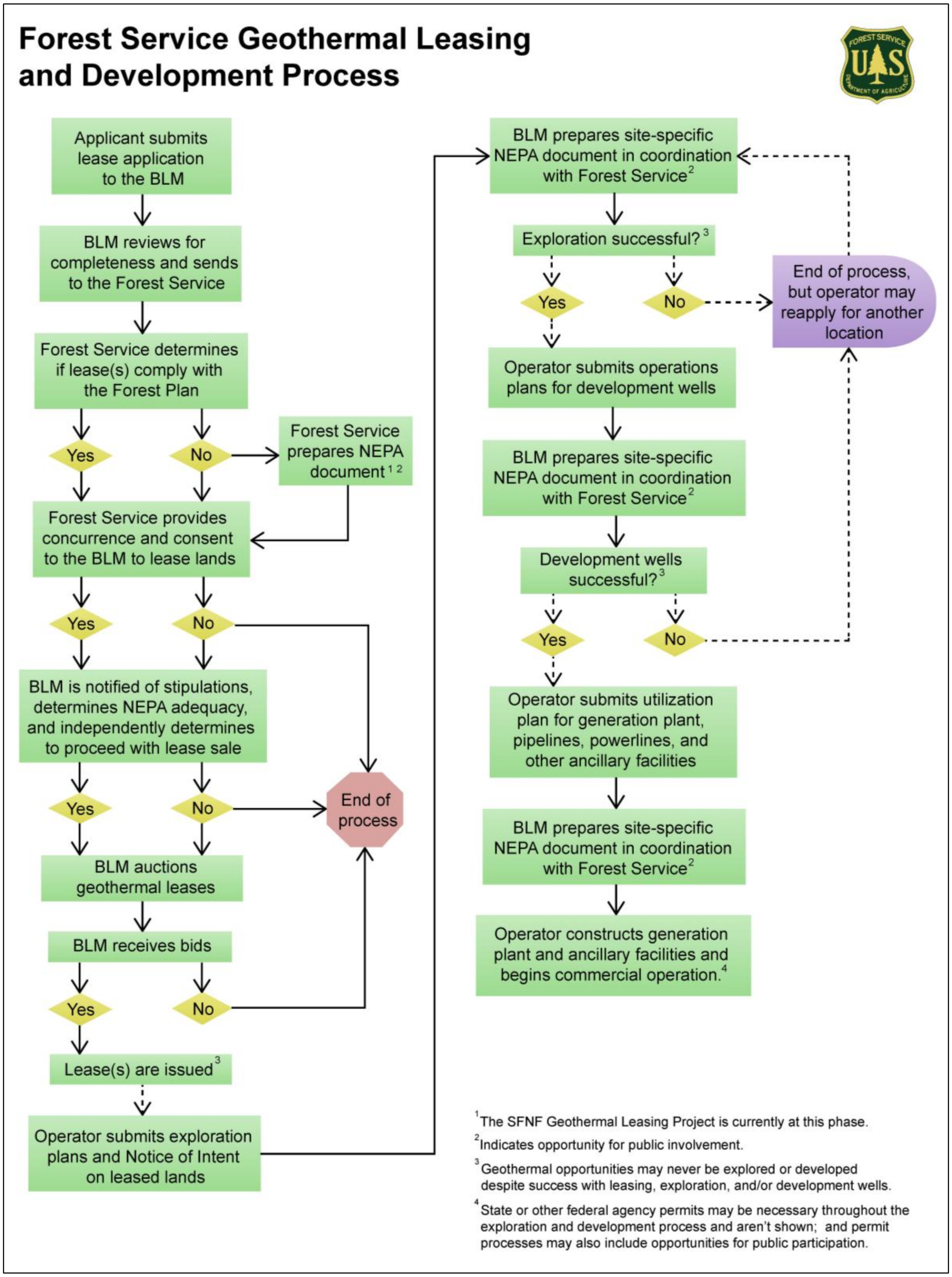

Figure 1-3. Geothermal Leasing and Development Process

1.6.1 Resource Geography

New Mexico contains abundant geothermal resources throughout a large temperature gradients. Temperature gradients refer to the rate of increasing temperature with respect to increasing depth. High temperature gradients can indicate the location and depth of potential underground geothermal reservoirs capable of supporting commercial uses. Resources suitable for most development are concentrated in the west and north-central regions of the state, with high temperature gradients ranging from 1.6°F to 2.5°F per 100 feet of depth (BLM and Forest Service 2008).

Within the project area, highly favorable geothermal resources are concentrated on lands next to the Valles Caldera National Preserve (VCNP), as shown on **Figure 1-4**, Geothermal Potential Areas (USGS 2010). KGRAs cover most lands in the project area south of Highway 96. Similarly, most lands identified as having geothermal development potential in the project area in the 2003 US DOE study are south of Highway 96 (DOE and BLM 2003).

1.6.2 Utilization

New Mexico’s first utility-scale geothermal power plant was completed at the Lightning Dock geothermal field in Hidalgo County in 2013, producing 4 MW of electricity (Geothermal Energy Association 2014). No other utility-scale production plants are in operation in New Mexico. Direct use applications of geothermal in New Mexico include greenhouses, heat pumps, and aquaculture operations.

1.6.3 Technical Capabilities

New Mexico universities, national laboratories, state agencies, local working groups, and private companies contribute technical capabilities to the local and national geothermal communities. Research conducted through Sandia National Laboratories has investigated drilling concepts and new technology and processes, including tools to make geothermal energy drilling more cost efficient. The concept of hot dry rock[1] geothermal technology originated at Los Alamos National Laboratory (LANL) in the early 1970s (Brown 2009). Numerous research and collaboration studies from the University of New Mexico have contributed to the understanding of geothermal and hydrothermal conditions in the state, including SFNF lands. New Mexico State University at Las Cruces has conducted geothermal research that resulted in the development of a geothermal space-heating system that at one point heated up to 30 campus buildings, such as dorms and athletic facilities (BLM and Forest Service 2008).

1.6.4 Electrical Power Generation and Capacity

In the near term, geothermal development in New Mexico is likely for small-scale power (BLM and Forest Service 2008). The USGS report titled Assessment of Moderate- and High-Temperature Geothermal Resources of the United States estimates a mean probability 170 MW of electrical power generation for identified geothermal resources on all lands in New Mexico during the next 30 years; it predicts a total low-high range of between 53 MW and 343 MW (Williams et al. 2008).

[1] Hot dry rock technology refers to the formation of a fully engineered geothermal reservoir in hot, crystalline rock by the application of hydro-shearing techniques and the subsequent circulation of water through that engineered reservoir to mine the thermal energy from the hot rock (Duchane and Brown 1995).

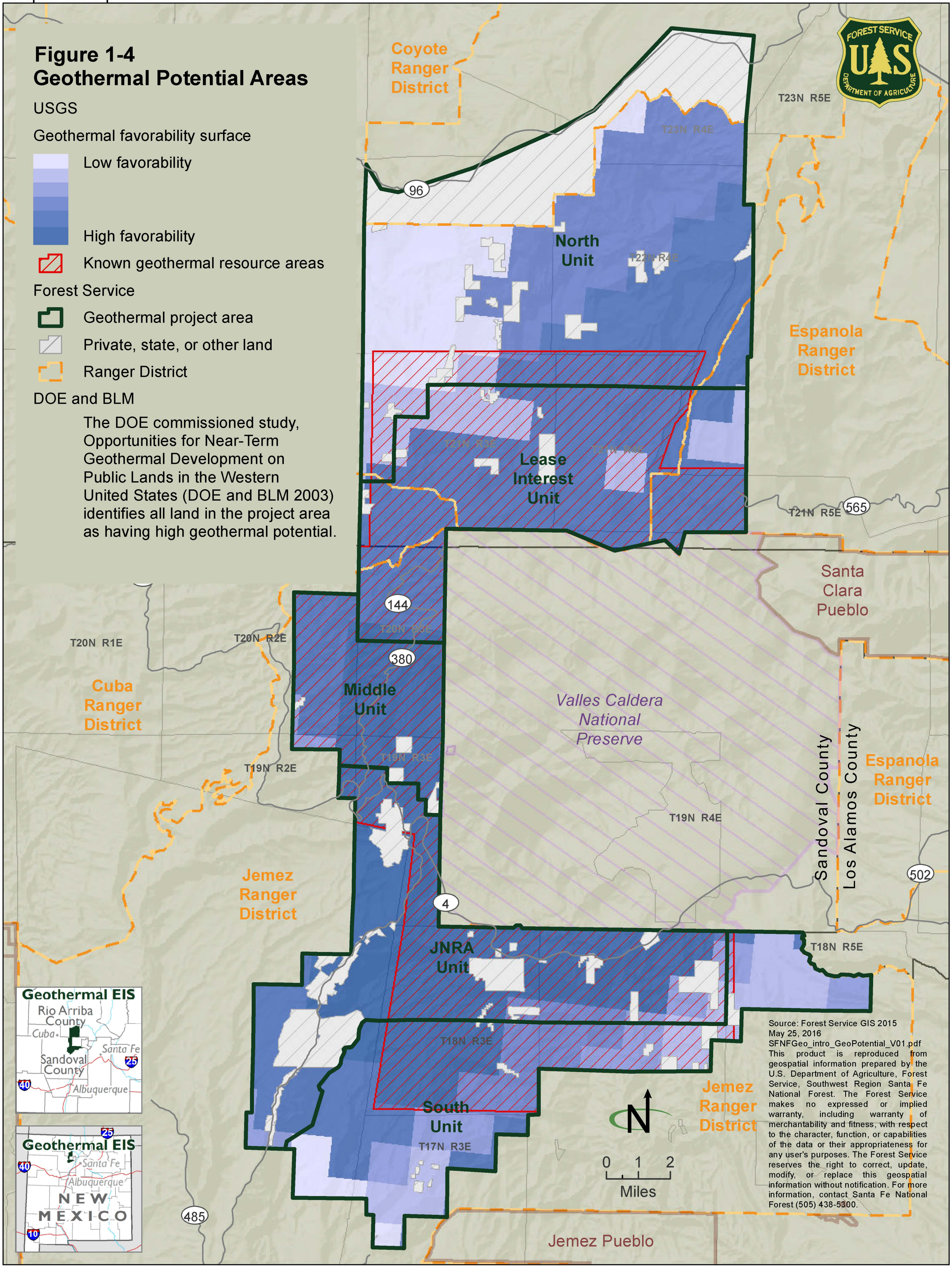
Figure 1-4
Geothermal Potential Areas
USGS
Geothermal favorability surface
Low favorability
High favorability
Known geothermal resource areas
Forest Service
Geothermal project area
Private, state, or other land
Ranger District
DOE and BLM
The DOE commissioned study, Opportunities for Near-Term Geothermal Development on Public Lands in the Western United States (DOE and BLM 2003) identifies all land in the project area as having high geothermal potential.
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Valles Caldera National Preserve
Sandoval County
Los Alamos County
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
T23N R5E
T23N R4E
T22N R4E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T18N R3E
T19N R4E
T18N R5E
T17N R3E
96
144
380
4
565
502
485
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
25
40
NEW MEXICO
10
N
0 1 2
Miles
Source: Forest Service GIS 2015
May 25, 2016
SFNFGeo_intro_GeoPotential_V01.pdf
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Lopez et al. (2012) investigated technical potential for hydrothermal and enhanced geothermal systems by state, given system performance, topographic limitations, environmental, and land-use constraints to estimate the upper boundary of development potential. In New Mexico, total estimated technical potential for hydrothermal is 2 gigawatts (GW), and enhanced geothermal systems is 180 GW (Lopez et al. 2012).

1.7 Relationship to Forest Service Plans, Policies, and Programs

1.7.1 Santa Fe National Forest Plan

The SFNF operates under the direction of the Santa Fe National Forest Plan, as amended (Forest Service 1987). The 1987 Forest Plan does not allocate lands as available or unavailable to geothermal leasing.

Goals and forest-wide standards and guidelines relevant to fluid mineral leasing and development (i.e., lands and minerals) are summarized below. Standards and guidelines specific to management areas in the project area are found in **Appendix A**, Management Areas and Prescriptions from Forest Plan. This list is not comprehensive but instead includes only management that is relevant to geothermal leasing. In 2015, the SFNF began the process of revising the Forest Plan. The results of this EIS will amend the 1987 Forest Plan.

1.7.1.1 Goals—Minerals

- Support sound energy and minerals exploration and development, where appropriate. Administer the mineral laws and regulations to minimize adverse surface resource impacts.

1.7.1.2 Goals—Lands

- Minimize the number of electronic sites and utility corridors by allowing only those that are most appropriately located on Forest lands. Use existing corridors, whenever possible from a need and resource management standpoint.

1.7.1.3 Forest-Wide Standards and Guidelines—Minerals

- ***G01***—Review with the BLM existing withdrawals to ensure compliance with FLPMA. Consider release for exploration and development while adequately protecting surface resources. (Note: Forest Service Manual 2561.25 provides direction on managing groundwater resources in addition to surface resources).
- ***G04***—Respond in a timely manner to oil and gas, geothermal, and other mineral lease applications. Response will normally be within 30 days of receipt of application, but extensive public involvement or environmental analysis needs may require more time. Such needs will be fully coordinated with the BLM.
- ***G05***—Control surface uses in mineral operations through plans of operation and permits that provide for the following:
    - Meeting visual quality objectives
    - Preserving water quality
    - Protecting watershed values
    - Reclaiming the surface to original or characteristic contours or adapting it to serve further surface resource uses

- Revegetating or reforesting the surface with appropriate plant species to attain soil stability
- Protecting cultural resources
- Protecting threatened and endangered species and other wildlife habitats

- ***G06***—Ensure mineral areas are restored to repair resource damage and remove public safety hazards, as needed. Reclamation will be managed for progressive development and rehabilitation. Operating plans, including appropriate bonding, will be the means for accomplishing this. Backlog work will be programmed and accomplished as opportunities arise and funding is made available.

1.7.1.4 Forest-Wide Standards and Guidelines—Lands and Utility Corridors

- Provide for joint use in corridors and combine uses to the extent possible in light of technical and environmental constraints. All requests for utility corridors will require a comprehensive NEPA environmental analysis. Each management area has been evaluated as to suitability for corridor location. The suitability classifications are as follows:
  - Exclusion area—No utility corridors are allowed.
  - Avoidance area—Utility corridors are not consistent with management area emphasis and may require extensive mitigation measures.
  - Unclassified area—Utility corridors are permitted after normal environmental analysis.

1.7.2 Memorandum of Understanding Between Forest Service and BLM: Implementation of Section 225 of the Energy Policy Act of 2005 Regarding Geothermal Leasing and Permitting

In 2006, the BLM and Forest Service signed a Memorandum of Understanding (MOU) to facilitate interagency coordination between the Forest Service and BLM, and establish policies and procedures to implement Section 225 of the Energy Policy Act of 2005, Public Law 109-58. Section 225 requires the coordination of geothermal leasing and permitting on public lands and NFS lands between the Secretary of the Interior and Secretary of Agriculture.

The MOU establishes that the Forest Service will take the lead for completing pre-lease NEPA documents and is responsible for providing the official Forest Service consent or non-consent to leasing on NFS lands. The Forest Service and BLM will also identify, through the analysis, reasonable and justifiable stipulations needed to protect or minimize impacts on specific resources or land uses.

1.7.3 Programmatic Environmental Impact Statement for Geothermal Leasing Exploration and Development

The BLM and Forest Service prepared the 2008 Geothermal PEIS to assess the environmental impacts from developing and implementing the geothermal program. It facilitated environmentally responsible utility-scale geothermal energy development in the following Western states: Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. Additionally, the 2008 Geothermal PEIS allocated NFS lands as open or closed to being considered for geothermal leasing. It also adopted stipulations and BMPs and explained the procedures for geothermal leasing and development (BLM and Forest Service 2008).

The Forest Service determinations resulting from the 2008 Geothermal PEIS and ROD are as follows:

- Identified those NFS lands legally open or closed to leasing
- Developed an RFDS for a potential for 12,210 MW of electrical generating capacity from 244 power plants in the 12 western states by 2025, plus additional direct uses of geothermal resources
- Included stipulations, BMPs, and procedures for geothermal leasing and development
- Recognized that, before making a leasing decision on lands near an National Park Service (NPS) unit, the BLM or other surface management agency must determine if there would be any impacts on thermal or hydrological features in the unit, in accordance with the Geothermal Steam Act Amendments (30 USC, Section 1026)

The 2008 Geothermal PEIS noted that designating lands for geothermal leasing potential and amending a land use plan, in and of itself, does not cause any direct impacts, as defined by the Council on Environmental Quality (CEQ) regulations (40 CFR, Part 1508.8[a]). However, it is reasonable to foresee that on-the-ground impacts would occur if the BLM were to issue geothermal leases but that the impacts would not occur until the future. Therefore, the 2008 Geothermal PEIS addressed both direct and indirect impacts based on the foreseeable on-the-ground actions, including exploration, drilling, and utilization.

In Volume I, these impacts were not analyzed site specifically but generically and programmatically for the 2008 Geothermal PEIS project area, based on the RFDS. The 2008 Geothermal PEIS analyzed the broad impacts associated with allocation of geothermal resources for leasing. It also analyzed the adoption of stipulations and BMPs, based on the assumptions presented in the RFDS, in assessing the likely impacts from development following leasing in the project area.

Volume II of the PEIS provided lease-specific analysis to decision-makers to aid them in deciding on whether to issue or deny 19 geothermal lease applications that were pending as of January 1, 2005. Pending lease applications did not include lands on the SFNF, and no site-specific analysis for issues associated with on-the-ground actions of geothermal exploration, drilling, utilization, or reclamation and abandonment was conducted. Additionally, the 2008 Geothermal PEIS did not result in a consent determination on NFS lands. Before conducting lease sales, the Forest Service must provide the BLM with a consent determination (including terms and conditions or stipulations). As such, this document alone is insufficient to proceed with geothermal lease sales and issuance of competitive and noncompetitive leases. The 2008 Programmatic EIS provides the basis for consent decisions covered in this EIS.

1.8 Scope of Analysis

The 2008 Geothermal PEIS included an analysis of the potential effects of utility-scale geothermal energy development on public lands. That analysis was designed to provide environmental consequences, in accordance with NEPA, to support the decision, which identified lands legally open to leasing. The SFNF Geothermal Leasing EIS is a separate analysis process, with the following purposes:

- Determines if lands in the project area are available for the BLM to lease and, if so, under what stipulations for protection of surface resources
- Describes the RFDS for the project area

- Examines the existing environmental setting
- Describes the potential direct, indirect, and cumulative impacts on the human and natural environment associated with implementing a range of alternatives

Because the planning and decision area for the SFNF Geothermal Leasing EIS is in the study area covered by the 2008 Geothermal PEIS analysis, this EIS will "tier" to the PEIS. Tiering refers to the coverage of general matters in a broader EIS; subsequent narrower EISs or environmental assessments, such as this one, incorporate by reference the general discussions and concentrate solely on the issues specific to the EIS or environmental assessment subsequently prepared (40 CFR, Part 1508.28). Tiering typically results in a more efficient environmental analysis process for future development proposals. The determination of the necessary level of additional NEPA analysis is made on a case-by-case basis at the time a project is proposed.

This EIS will tier to those elements of the 2008 Geothermal PEIS that are appropriate for such use (e.g., resource impact analysis, stipulations, leasing procedures, and BMPs). Because the SFNF Geothermal Leasing EIS presents different site-specific issues than those addressed in the 2008 Geothermal PEIS, the analysis for this EIS has been refined and may include other protective provisions specific to the project area.

The scope of this analysis does not evaluate surface-disturbing geothermal exploration or development proposals. Subsequent site-specific projects would require future environmental analysis, which could tier to this EIS and the 2008 Geothermal PEIS. The appropriate level of environmental analysis would be determined by the authorizing officer.

1.9 Decision Framework

Given the purpose and need, the deciding official reviews the proposed action, the other alternatives, and the environmental consequences in order to make the following decisions:

- What lands would be made available for leasing through a consent determination and any stipulations that would be included in future leases the BLM may issue
- What lands would not be available for leasing

This decision would not authorize lease sale or development of parcels.

1.10 Public Involvement and Scoping

The formal public scoping comment period, as required by NEPA (40 CFR, Subpart 1501.7), began on May 13, 2015, and ended on June 26, 2015. Scoping included the following:

- Notice of intent (NOI) published in the *Federal Register* on May 13, 2015;
- Media outreach, including press releases and project website (http://www.fs.usda.gov/project/?project=46886)
- Scoping letter mailing to those on the project mailing list, including federal, state, and local agencies, Native American tribes, special interest groups, and landowners
- Public scoping meetings

The NOI published was entitled Santa Fe National Forest; New Mexico; Geothermal Leasing. It noted that comments concerning the scope of the analysis must be received by June 12, 2015 (on June 8, 2015, the SFNF issued a news release indicating the scoping period was extended to June

26). The NOI also provided an overview of the proposed action, purpose and need for the project, and instructions for submitting comments.

The SFNF issued a press release on May 13, 2015, announcing its intent to prepare an EIS. The press release included a link to the NOI, which was published that day. On May 26, 2015, the SFNF issued a second press release that included dates, times, and locations for the two scheduled public scoping meetings, as well as information on how written comments could be submitted. On June 8, 2015, a third press release was issued indicating the SFNF had extended the deadline for public comments on the scope of the environmental analysis from June 12 to June 26, 2015, to give the public more time to submit comments on the proposed project.

On May 22, 2015, the SFNF e-mailed a scoping letter and scoping document to federal, state, and local agencies, special interest groups, landowners, and other interested individuals. Hard copies of the scoping letter were also mailed to individuals with no e-mail address on file. The scoping letter provided a brief overview of the project and included dates and locations of the two public meetings and instructions for submitting written comments. The scoping document provided a more detailed description of the project: leasing background information, purpose and need for action, decision to be made, preliminary issues, scoping process, analysis process, and figures showing the project area and proposed closures.

Public scoping meetings were held on June 1, in Cuba, New Mexico and on June 2 in Santa Fe. Forest Service staff were available at the meetings to answer questions from attendees, who were encouraged to submit written comments so that their concerns could be accurately conveyed and formally addressed in the EIS. Comment forms were available at the meetings for attendees to fill out and either submit at the meeting or mail in later.

Results of the public scoping are discussed in detail in the scoping report posted on the project website.

1.11 Tribal Coordination

The Forest Service consults on a government-to-government basis with Native American tribes. Consultation and coordination with Native American tribal governments have begun and are ongoing.

The SFNF consulted with the following federally recognized tribes in the region: Pueblo of Acoma; Pueblo of Isleta; Kewa Pueblo (Pueblo of Santa Domingo); Pueblo of Nambé; Pueblo of Cochiti; Pueblo of Jemez; Pueblo of Laguna; Ohkay Owingeh; Pueblo of Picuris; Pueblo of San Ildefonso; Pueblo of Santa Clara; Pueblo of Pojoaque; Pueblo of San Felipe; Pueblo of Santa Ana; Pueblo of Taos; Pueblo of Tesuque; Pueblo of Zia; Pueblo of Zuni; Jicarilla Apache Nation; Ojo Encino Navajo Chapter House; Pueblo Pintado Navajo Chapter House; Canoncito Navajo Chapter House; Ramah Navajo Chapter House; Counselor Navajo Chapter House; Crownpoint Navajo Chapter House; Torreon Navajo Chapter House; Whitehorse Lake Navajo Chapter House; Mescalero Apache Tribe; The Hopi Tribe; The Navajo Nation; Southern Ute Tribe; Ute Mountain Ute Tribe.

The SFNF began consultation before the formal scoping period by mailing a briefing paper to tribes on October 14, 2014, which provided an overview of the project, and current status. Additionally, meetings were held with tribes in October, 2014, to present information related to the project and answer questions. The SFNF held meetings with the following tribes: Pueblo of Jemez; Pueblo of Zia; Pueblo of Cochiti; Pueblo of Santa Domingo; Pueblo of San Ildefonso;

Ohkay Owingeh; Pueblo of Santa Clara; Jicarilla Apache Nation; Counselor Navajo Chapter House; and Torreon Navajo Chapter House. Scoping letters were sent to the list of consulted tribes describing the project, date, and times of the public meetings and requesting consultation. The letters requested information on issues or concerns with historic properties in the project area under Section 106 of the National Historic Preservation Act. The SFNF held meetings with the San Felipe and Santa Clara Pueblo in July and September 2015.

1.12 Issues

The Forest Service separated the issues into two groups: significant and non-significant. Significant issues were defined as those directly or indirectly caused by implementing the proposed action. Non-significant issues were identified as the following:

- Those outside the scope of the proposed action
- Those already decided by law, regulation, Forest Plan, or other higher level decision
- Those irrelevant to the decision to be made
- Those conjectural and not supported by scientific or factual evidence

NEPA regulations explain this delineation in Sec. 1501.7, "…identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (Sec. 1506.3)…." A list of non-significant issues and reasons regarding their categorization as such can be found in the project record.

As for significant issues, the Forest Service identified the following issues during scoping:

1.12.1 Timing and Scope of the Proposal

- Issue—Is the timing and scope of the proposal appropriate, considering the size of the project area relative to expression of interest area and the ongoing Forest Plan revision process?
- Issue—Considering previous geothermal exploration in the region, how viable is commercial geothermal development in the project area?
- Issue—Are there other agencies besides the BLM and NPS that should serve as cooperating agencies on this project?

1.12.2 Land Use, Recreation, and Special Designations (Including Inventoried Roadless Areas)

- Issue—How would geothermal leasing impact inventoried roadless areas (IRAs) and sensitive resources in IRAs?
- Issue—How would geothermal leasing impact adjacent wilderness areas, lands with wilderness characteristics, IRAs, and Areas of Critical Environmental Concern (ACECs) or other special designations?
- Issue—How would geothermal leasing affect recreation in the project area? How would geothermal leasing affect the JNRA and other nearby recreation areas managed by other federal or state agencies?

1.12.3 Geologic Resources

- Issue—What are the impacts on geologic resources from geothermal developments? Could there be increased risk for induced seismicity or other geologic hazards as a result of geothermal leasing? If so, what are the indirect effects of geologic hazards, considering the proximity of the Abiquiu Dam and LANL?

- Issue—Is baseline seismic monitoring or additional fault mapping required to determine the risks of induced seismicity or other geologic hazards associated with geothermal exploration or development?

1.12.4 Water Resources and Quality

- Issue—How would geothermal leasing affect surface and subsurface water quantity? Would geothermal leasing change or reduce water allocations for other uses? What are the short- and long-term effects on the regional aquifer?
- Issue—How would geothermal leasing affect water quality, and what size buffers are necessary to protect surface waters? How might these effects differ, depending on the type of geothermal system?
- Issue—How would geothermal leasing affect the Abiquiu Reservoir and Dam and the New Mexico Department of Game and Fish (NMDGF) Habitat Stamp Program water projects?

1.12.5 Air Quality and Air Quality-Related Values

- Issue—How would gases and emissions from geothermal leasing be monitored and controlled, and how would residual waste accumulations from air emission management be disposed of?
- What are the effects of odors from geothermal leasing, and how would these affect receptors in the project area?

1.12.6 Vegetation

- Issue—How would vegetation loss from geothermal leasing affect soil erosion?
- Issue—How would noxious and invasive weeds be managed in geothermal leasing areas?

1.12.7 Wildlife

- Issue—What are the short- and long-term effects of geothermal leasing on cold water fisheries, wildlife corridors, critical wildlife habitat areas, fish hatcheries, and other important or sensitive fish and wildlife habitats in the project area?

1.12.8 Threatened and Endangered Species and Special Status Species

- Issue—What are the effects of geothermal leasing on the Mexican spotted owl, Jemez Mountain salamander, New Mexico meadow jumping mouse, Jemez woodland snail, Rio Grande cutthroat trout (RGCT), and other threatened and endangered or special status species in the project area? What stipulations and mitigation measures are necessary to protect these species?
- Issue—Would geothermal leasing displace other resource uses on the forest, such as recreation and livestock grazing, into or near threatened and endangered species or special status species' habitats?

1.12.9 Livestock Grazing

- Issue—How would geothermal leasing affect grazing allotments and grazing forage?

1.12.10 Cultural Resources

- Issue—How would cultural resources be affected by geothermal leasing, and how would these effects be managed?

1.12.11 Tribal Interests and Traditional Cultural Properties

- Issue—How would traditional cultural properties and tribal interests be affected by geothermal leasing, including those in confidential locations, and how would those effects be managed? What are the direct, indirect, and cumulative impacts of other resource impacts on tribal interests?

1.12.12 Visual Resources

- Issue—What are the visual impacts associated with geothermal leasing, including construction of transmission lines and water vapor from geothermal plants?

1.12.13 Social Interests, Economics, and Environmental Justice

- Issue—How would geothermal leasing affect tourism, local businesses, property values, and community services?
- Issue—Would geothermal leasing result in disparate impacts on communities, tribes, or other populations?

1.12.14 Health and Safety

- Issue—What are the health and safety risks of geothermal leasing? How would geothermal leasing affect drinking water, considering the regional geology?

1.12.15 Noise

- Issue—What are the impacts of increased noise in the project area?

1.12.16 Transportation and Access

- Issue—How would increased traffic affect residents, visitors, and other forest users? What would be the impacts on road conditions and adjacent buildings as a result of increased traffic?
- Issue—How would geothermal leasing affect public access to the SFNF?

1.12.17 Climate Change

- Issue—How would the SFNF address climate change and greenhouse gas (GHG) emissions from geothermal leasing?
- Issue—Would geothermal leasing affect regional weather conditions?

1.12.18 Fire

- Issue—What stipulations and mitigation measures are necessary to reduce the risk of wildfire associated with geothermal energy transmission?

1.12.19 National Park Service Values[2]

- Issue—How would geothermal leasing affect the natural, cultural, and sensory resource values of the Bandelier National Monument and Valles Caldera National Preserve, and what stipulations and mitigation measures are necessary to protect these values?

1.13 Proposed Action

The Forest Service's proposed action is to determine which lands in the SFNF on the Coyote, Cuba, Espanola, and Jemez Ranger Districts would be available for geothermal leasing and under what stipulations. This would be implemented by amending the SFNF Forest Plan or by incorporating the decisions into the revised Forest Plan.

Under the proposed action, certain lands in the project area are excluded from geothermal leasing on the basis of existing laws, regulations (43 CFR, Part 3201.11), and executive orders. Non-discretionary closures are for the JNRA (28,900 acres).

In addition to non-discretionary closures, the Forest Service has the administrative authority to issue discretionary closures to protect special resource values. The following areas are proposed Forest Service discretionary closures for geothermal leasing:

- Administrative site withdrawals
    - Seven Springs (7 acres)
    - Encino (184 acres)
    - Encino Point (120 acres)
    - Cerro Pelado Lookout (160 acres)

About 29,321 acres of NFS lands would be closed by law, regulations, or other authority to geothermal leasing in the project area. This represents about 17 percent of the NFS lands in the project area.

All other lands in the project area would be allocated as open to leasing, subject to existing laws, regulations, formal orders, stipulations attached to the lease form, and terms and conditions of the standard lease form.

No surface occupancy (NSO), controlled surface use (CSU), and timing limitation (TL) stipulations would be implemented on lands allocated as open to leasing, in accordance with the guidance provided in the Geothermal PEIS. These allocations are described in detail in **Chapter 2**.

The lessee and the appropriate federal agency would monitor lease stipulations, conditions of approval, and the general operation of geothermal developments to ensure their continued effectiveness through all phases of development. Using adaptive management strategies, where mitigation measures are determined to be ineffective at meeting the desired resource conditions, the BLM and Forest Service would take steps to determine the cause and would require the

[2] Issues specific to National Park Service values are discussed under Section 3.17, Visual Resources; Section 3.20, Noise; Section 3.15, Cultural Resources; Section 3.16, Tribal Interests and Traditional Cultural Resources; Section 3.11, Vegetation; Section 3.12, Fish and Wildlife; and Section 3.13, Threatened and Endangered Species and Special Status Species.

operator to take corrective action. This information would also be used to inform future geothermal leasing and development.

Chapter 2. Alternatives, Including the Proposed Action

2.1 Introduction

This chapter provides the details of the proposed action, the alternatives to the proposed action, a discussion of alternatives considered but eliminated from detailed analysis, and an overview of the RFDS for geothermal resources in the SFNF. Also in this section is a comparison of the alternatives, sharply defining the differences between each alternative and providing a clear basis for choice among options by the decision-maker and the public.

After the public scoping period closed on June 26, 2015, the SFNF began developing alternatives. Based on public input, the interdisciplinary team's analysis of the current management situation and resource data, and the defined purpose and need for the project, the Forest Service developed four alternatives, including a no action alternative. Each of the alternatives denotes whether the SFNF would consent to leasing land in the decision area and which lease stipulations would apply. Differences between alternatives are expressed by whether the SFNF would consent to leasing land and the degree of stipulation constraints applied to those areas.

2.1.1 Identified Lands Available for Geothermal Leasing

The geothermal leasing regulations (43 CFR, Part 3201) describe the types of lands available and unavailable for geothermal leasing. The BLM may issue geothermal leases on Forest Service lands that are available for leasing in the land use planning process. Exceptions to this are identified as lands closed to geothermal leasing; this denotes an area that is not available for geothermal leasing, exploration, or development for nondiscretionary or discretionary reasons. The 2008 Geothermal PEIS identified certain classifications of lands as excluded from geothermal leasing, based on a nondiscretionary or discretionary basis. Nondiscretionary closures would be for lands that are excluded based on existing laws, regulations (43 CFR, Subpart 3201.11), and executive orders. For both the action and no action alternatives, nondiscretionary closed lands or lands where consent would not be granted for leasing are approximately 28,900 acres of NFS lands in the JNRA (of the 32,900 total acres—including non-NFS lands—in the JNRA).

2.2 Stipulations, Best Management Practices, and Procedures

This section describes the types of constraints that would be applied as appropriate to any new leases for lands that are available for geothermal leasing. The SFNF developed stipulations, BMPs, and procedures based on the 2008 Geothermal PEIS and through the assessment process for this EIS. These stipulations were selected for inclusion based on a comprehensive review of the SFNF Forest Plan, program guidance, geothermal development activities, published data on geothermal development impacts, industry standards, and best professional judgment. Other reports on fluid mineral leasing and development (e.g., oil and gas) were consulted because of the similarity of most of the activities and impacts, such as from exploration, drilling, and site development. Where the agency determines that particular stipulations may be inappropriate for a planning area, the procedures for waivers, exceptions, and modifications would be followed.

A detailed description of stipulations by alternative is provided in **Appendix B**, Geothermal Leasing Stipulations by Alternative. A list of BMPs is provided in Appendix C, Best Management Practices and Mitigation Measures.

2.2.1 Lease Stipulations

Lease stipulations are major or moderate constraints applied to a new geothermal lease. A lease stipulation is a condition of lease issuance that provides a level of protection for other resource values or land uses by restricting lease operations during certain times or at certain locations or by mitigating unacceptable impacts, to an extent greater than standard lease terms or conditions. A stipulation is an enforceable term of the lease contract; it supersedes any inconsistent provisions of the standard lease form and is attached to and made a part of the lease. Lease stipulations further implement the Forest Service's and BLM's regulatory authority to protect resources or resource values.

Stipulations provided in this EIS would serve as the minimal level of protection and would be adopted into the Forest Plan when the ROD is signed. It may be necessary to add, delete, or modify lease stipulations in the Forest Plan. This would happen as a result of pre-lease issuance parcel reviews, statewide lease stipulation consistency reviews, plan amendments, changed circumstances on the ground, or changed resource protection priorities. This is accomplished and documented either through the plan maintenance process (for minor changes consistent with an approved plan) or the plan amendment process (for changes resulting in modification of terms, conditions, or decisions in an approved plan).

More than one stipulation may apply to a parcel of land. For example, a parcel may have an NSO stipulation to protect a property listed on the National Register of Historic Places (NRHP), a CSU stipulation to protect a recreation area, and a TL for big game winter range.

2.2.2 Lease Exceptions, Waivers, and Modifications

To ensure leasing decisions remain appropriate in light of continually changing circumstances and new information, the Forest Service and BLM develop and apply lease stipulation exceptions, waivers, and modification criteria. An exception, waiver, or modification (defined below) may not be approved unless the BLM Authorized Officer determines that the factors leading to the stipulation's inclusion in the lease have changed sufficiently to make the protection provided by the stipulation no longer justified, or the proposed operations would not cause unacceptable impacts (43 CFR, Subpart 3101.1-4).

- An **exception** is a one-time exemption for a particular site within the leasehold and is determined on a case-by-case basis; the stipulation continues to apply to all other sites within the leasehold. An exception is a limited type of waiver.
- A **waiver** is a permanent exemption from a lease stipulation. The stipulation no longer applies anywhere within the leasehold.
- A **modification** is a change to the provisions of a lease stipulation, either temporarily or for the term of the lease. Depending on the specific modification, the stipulation may or may not apply to all sites within the leasehold to which the restrictive criteria are applied.

Requests from the operator should contain, at a minimum, a plan with the following information:

- Related on-site or off-site mitigation efforts, to adequately protect affected resources
- Data collection and monitoring efforts

- Time frames for beginning and completing the proposed project

The BLM Authorized Officer will require the operator to submit a written request for an exception, waiver, or modification and information demonstrating one of the following:

- The factors leading to the inclusion of the stipulation in the lease have changed sufficiently to make the protection provided by the lease stipulation no longer justified.
- The proposed operation would not cause unacceptable impacts.

The SFNF must analyze and document how the exception, waiver, or modification conforms with the Forest Plan. It must identify the plan decision (including goals, objectives, or desired outcomes) supported by the proposed exception, waiver, or modification. If existing NEPA analysis does not support the exception, waiver, or modification, the Forest Service must conduct the appropriate environmental review and NEPA analysis. If the proposed exception, waiver, or modification is not in conformance with the Forest Plan or that document does not disclose the conditions under which such proposed change would be allowed, the Forest Service must either amend the plan or deny the request for exception, waiver, or modification.

During the review process, the BLM Authorized Officer will coordinate with other state or federal agencies, as appropriate, and will document the outcome. For example, it may be appropriate to coordinate the review of wildlife exceptions, waivers, and modifications with NMDGF staff; review and recommendations will be documented, along with any necessary mitigation, and provided to the BLM Authorized Officer for approval or disapproval. The applicant will then be provided with a written notification of the decision.

Public notification (30-day public review), if required, should both identify the modified lease terms and describe the affected lands on a map. When public notification is required, the following procedures may apply:

- **Approval of an exception, waiver, or modification at the same time the ground-disturbing activity is approved—**A notice describing the modified lease terms, when required, may be posted for 30 days in the SFNF offices, on the SFNF website, or in a local paper as a legal notice or incorporated into a newspaper article. Or the notice may be included as part of the NEPA document's public review, if the document is offered for review.
- **Approval of an exception, waiver, or modification after the ground-disturbing activity is approved—**Public notice, if required, may take the form of a 30-day posting on the SFNF website, a legal notice or article in the newspaper, or a notice and associated public review conducted as part of the NEPA analysis process.

2.2.3 No Surface Occupancy Lease Stipulation

NSO stipulations are considered a major constraint, because they do not allow for surface development. For example, a lessee of an NSO area must develop any surface infrastructure outside the NSO area. The lessee would need to use advanced technology, such as directional drilling, to access the geothermal resource under the NSO area. An NSO is appropriate when the standard terms and conditions, CSU stipulations, TLs, and BMPs for permit approval are determined to be insufficient to achieve the resource protection objectives.

2.2.4 Timing Limitations and Controlled Surface Use Lease Stipulations

Where standard lease terms and permit-level decisions are deemed insufficient to protect sensitive resources but where an NSO is deemed overly restrictive, the Forest Service would apply seasonal or TL or CSU stipulations to leases.

In general, TLs are used to protect resources that are sensitive to disturbance during certain periods. Such stipulations are generally applicable to specific areas, seasons, and resources. They are commonly applied to wildlife activities and habitat, such as winter range for deer and elk, nesting habitat for raptors and migratory birds, and wildlife breeding areas. The SFNF Authorized Officer would apply TLs as appropriate for the specific lease areas.

A CSU allows the Forest Service to require that any future activity or development be modified or relocated from the proposed location if necessary to protect resources. The project applicant would be required to submit a plan to meet the resource management objectives through special design, construction, operation, mitigation, or reclamation measures or relocation. Unless the plan is approved, surface occupancy would not be allowed in the CSU stipulation area.

2.2.5 Best Management Practices

In addition to lease stipulations, during any subsequent exploration, drilling, utilization, or reclamation and abandonment of geothermal resources, the SFNF may require project-specific mitigation measures to permits. A list of BMPs, provided in **Appendix C**, was developed based on the following:

- Programmatic EIS for Geothermal Leasing in the Western United States (BLM and Forest Service 2008)
- Forest Service National Best Management Practices for Water Quality Management on National Forest System Lands
- Forest Service Handbook (Southwestern Region) FSH 2509.22 – Soil and Water Conservation Handbook
- Santa Fe National Forest Plan, as amended (Forest Service 1987)

The BMPs detailed in Appendix C would be incorporated as appropriate into the permit application or would be included in the approved use authorization by the BLM as COAs. When implementing the BMPs, the BLM and Forest Service would work with an affected lessee early in the process to explain how BMPs may fit into its development proposals and how BMPs can be implemented with the least economic impact on the lessee.

The BLM and Forest Service would discuss potential resource impacts with the lessee and would seek the operator's recommended solutions. The BLM and Forest Service would also encourage the lessee to incorporate necessary and effective BMPs into its project proposals, as determined to be appropriate during site-specific, project-level environmental analysis. BMPs not incorporated into the lessee's permit applications may be considered and evaluated through the environmental review process and incorporated into the use authorization as COAs or right-of-way (ROW) stipulations.

2.2.6 Monitoring

The lessee and the appropriate federal agency would monitor such measures as lease stipulations and COAs, as well as the general operation of geothermal developments. This would be done to ensure the continued effectiveness of the stipulations and COAs through all phases of development, as described in the 2008 Geothermal PEIS (BLM and Forest Service 2008). Using adaptive management strategies, where mitigation measures are determined to be ineffective at meeting the desired resource conditions, the BLM and SFNF would determine the cause and would require the operator to take corrective action. The two agencies would also use this information to inform future geothermal leasing and development.

2.2.7 Procedures Prior to Leasing

Pre-lease procedures would follow guidance identified in the 2008 Geothermal PEIS (BLM and Forest Service 2008). The stipulations listed above would also be used to help achieve resource protection, in accordance with laws and regulations.

The SFNF would provide a consent determination (including terms and conditions or stipulations) to the BLM prior to any parcels on NFS lands being offered for lease sale.

2.3 Alternatives Considered in Detail

After the public scoping period closed, on June 26, 2015, the SFNF began developing alternatives. The Forest Service developed four alternatives, including the No Action Alternative. This was based on public input, the interdisciplinary team's analysis of the current management situation and resource data, and the defined purpose and need for the project. Much of the geographic information system (GIS) data used in developing the alternatives is based on remote sensing, and has not been field verified.

A summary of lands closed and available to leasing for the action alternatives is provided in **Table 2-1**. For figures showing the locations of closures and stipulations, see **Appendix B**, Stipulations and Closures by Alternative.

Table 2-1. Summary of Acres Open and Closed to Geothermal Leasing, by Alternative[1, 2, 3]

Allocation	Alternative		
	Alternative 2 Acres/percent of decision area	**Alternative 3 Acres/percent of decision area**	**Alternative 4 Acres/percent of decision area**
Closed to geothermal leasing	32,000 19	168,600 100	28,900 17
Open to geothermal leasing, subject to NSO stipulations	132,900 79	0 0	122,500 73
Open to geothermal leasing, subject to CSU stipulations	80,300 48	0 0	122,600 73
Open to geothermal leasing, subject to TLs	39,500 23	0 0	42,200 25

Table 2-1. Summary of Acres Open and Closed to Geothermal Leasing, by Alternative[1, 2, 3]

Allocation	Alternative		
	Alternative 2 **Acres/percent of decision area**	**Alternative 3** **Acres/percent of decision area**	**Alternative 4** **Acres/percent of decision area**
Open to geothermal leasing, subject to standard lease terms and conditions	1,400 1	0 0	3,800 2
Available for surface occupancy[4]	3,700 2 (largest parcel = 300 acres)	0 0	17,200 10 (largest parcel = 1,900 acres)

Source: Forest Service GIS 2015

[1] NSO, CSU, and TLs do not overlap areas closed to leasing

[2] NSO, CSU, and TLs overlap each other, as exceptions, modifications, or waivers may be applied to some stipulations, and the lesser stipulation would still be applied

[3] Acres identified as closed or open to geothermal leasing, subject to stipulations, are not provided for in Alternative 1, as the SFNF would not make an availability determination for geothermal leasing under this alternative.

[4] Lands that are neither closed to leasing nor subject to NSO stipulations are considered available for surface occupancy

2.3.1 Alternative 1—No Action

2.3.1.1 No Action

NEPA regulations require an agency conducting an EIS to “include the alternative of no action” (40 CFR, Subpart 1502.14). Under the no action alternative, the present course of management, based on the current forest plan, would continue.

Under the no action alternative, the SFNF would not make an availability determination for geothermal leasing on lands in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. The JNRA (approximately 28,900 acres) would remain closed to geothermal leasing. This alternative does not meet the purpose and need.

2.3.2 Alternative 2—The Proposed Action

Under the proposed action, land in the project area administered by the Forest Service would be identified as being closed to geothermal leasing, under either nondiscretionary or discretionary authorities, or would be identified as open to geothermal leasing, with possible moderate constraints (TLs and CSU stipulations) or major constraints (NSO stipulations).

2.3.2.1 Lands Closed to Leasing

The Forest Service has determined that certain lands in the project area are excluded from geothermal leasing on the basis of existing laws, regulations (see 43 CFR, Subpart 3201.11), and executive orders. This would be the case for NFS lands in the JNRA; approximately 28,900 acres.[1]

In addition to making nondiscretionary closures, the Forest Service has the administrative authority to issue discretionary closures to protect special resource values.

The following areas are proposed Forest Service discretionary closures for geothermal leasing:[2]

- Natural geothermal features, such as hot springs or other surface expressions of geothermal activity, and a 1-mile radius protection zone around them
- Administrative site withdrawals[3]
    - Seven Springs (7 acres)
    - Encino (184 acres)
    - Encino Point (120 acres)
    - Cerro Pelado Lookout (160 acres)

Approximately 32,000 acres of Forest Service lands would be closed (by law, regulations, or other authority) to geothermal leasing within the project area.

2.3.2.2 Lands Available for Leasing

Under the proposed action approximately 136,650 acres of the Forest Service lands in the project area would be available for geothermal leasing. This would be subject to existing laws, regulations, formal orders, and stipulations attached to the lease form and its terms and conditions.

No Surface Occupancy

NSO stipulations would apply to the following:[4]

- Designated or proposed critical habitat for listed species under the Endangered Species Act of 1973 (as amended) if it would adversely modify the habitat. For listed or proposed species without designated habitat, NSO would be implemented to the extent necessary to avoid jeopardy.
- Areas with important cultural and archaeological resources, such as

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[1] Wilderness areas and the segment of the East Fork of the Jemez River designated as wild under the Wild and Scenic Rivers Act were listed in the alternatives presented during the public scoping period. They are deleted because there are no wilderness areas within the project area, and the Wild segment of the East Fork of the Jemez River is within the JNRA.
[2] This list originally included National Historic Trails, but there are no designated National Historic Trails in the project area, the Jemez Mountain National Scenic Byway, Jemez Historic Site National Landmark, and Monument Canyon Research Natural Area, all of which are in the JNRA.
[3] This list originally included La Cueva, Sulphur Flat, and Las Conchas, all of which are in the JNRA.
[4] NSO stipulations were originally proposed for the segments of the East Fork of the Jemez River designated as Scenic or Recreational; however, these segments are within the JNRA, which is closed to geothermal leasing. In addition, NSO stipulations were originally proposed for segments of rivers determined to be potentially eligible for status under the Wild and Scenic Rivers Act which have not been listed, but there are none within this category at present. Natural Geothermal Features were inadvertently listed as NSO; however, they are classified as not available for leasing.

- ♦ Traditional cultural properties and Native American sacred sites, as identified through consultation
- ♦ Properties listed on or eligible for listing on the NRHP, including National Landmarks and National Register Districts and Sites
- ♦ Additional lands outside the designated boundaries, to the extent necessary to protect values where the setting and integrity are critical to their designation or eligibility
- ♦ Areas that qualify for cultural resource protection, based on Forest Plan criteria

- Water bodies; perennial and intermittent rivers and streams;[5] wetlands, springs, and playas (mapped in the USGS National Hydrography Dataset [NHD]); riparian areas; 100-year floodplains surrounding some features are protected by a 500-foot-wide protection zone.
- Acequias[6] are not included in the NHD and will need to be delineated on-site. Acequias with water rights recognized by the NMOSE would be protected by a protection zone of 50 feet, measured horizontally from the outer edge of the ditch.
- Water sources recognized by the NMOSE are drinking water sources, wells, springs, and a one-mile protection zone around them.
- Slopes in excess of 40 percent.
- Soils with severe erosion potential.
- Developed recreation facilities, special-use permit recreation sites, and areas with significant recreational use with which geothermal development is deemed incompatible[7]
    - ♦ San Antonio Creek Recreation Area
    - ♦ Seven Springs Recreation Area
    - ♦ Paliza Recreation Area
- Forest Service lands with a Scenery Management System integrity level of very high.
- Inventoried roadless areas.

Approximately 132,900 acres of Forest Service lands would be available to leasing under Alternative 2, subject to NSO stipulations.

Controlled Surface Use

CSU stipulations would apply to the following areas and site conditions:

- Protection of slopes between 30 and 40 percent—This stipulation would be applied to minimize the potential for soil erosion on these slopes.[8]
- Protection of important dispersed recreational areas—This stipulation would be applied to minimize the potential for adverse impacts on recreational values, both motorized and nonmotorized, and the natural settings associated with the recreation.
- Protection of viewsheds with a Scenery Management System integrity level of high.

[5] Perennial and intermittent rivers and streams were added to this listing for clarity. Ephemeral streams were removed, and acequias were moved to their own NSO stipulation.
[6] Man-made ditches to bring irrigation water from the highlands to privately owned agricultural lands. A new NSO stipulation was created to address acequias.
[7] This list originally included Jemez Falls, East Jemez, Horseshoe Springs, Las Conchas, Jemez Canyon, Redondo, San Antonio Creek, Battleship Rock, La Cueva, Laughing Water, and Sulphur Flat Summer Home Area, all of which are in the JNRA.
[8] This CSU stipulation was added, because it had been inadvertently left off the original list.

Under Alternative 2, approximately 80,300 acres of Forest Service lands would be available to leasing, subject to CSU stipulations. Of these lands, approximately 78,200 acres are also subject to NSO stipulations.

Timing Limitation Stipulations

TLs would apply to the following areas:[9]

- Mexican spotted owl designated protected activity centers (PACs)—Drilling and construction would be prohibited between March 1 and August 31.
- Northern goshawk designated post-fledging areas—Drilling and construction would be prohibited between March 1 and September 30.
- Peregrine falcon eyrie nesting areas—Drilling and construction would be prohibited between March 1 and August 15.
- Elk Calving Areas—Drilling and construction would be prohibited between June 1 and July 31.[10]

Approximately 39,500 acres would be available to leasing under Alternative 2, subject to TL stipulations. Of these lands, approximately 23,800 acres are also subject to CSU stipulations, and approximately 39,400 acres are also subject to NSO stipulations.

Standard Lease Terms and Conditions

Under Alternative 2, approximately 1,400 acres would be open to leasing, subject to standard lease terms and conditions; that is, they would not be subject to closures or NSO, CSU, or TL stipulations, as described above.

Notice to Lessee

The notice to lessee of no vegetation clearing between May 15 and July 31 would be applied in migratory bird nesting areas.

2.3.3 Alternative 3—No Leasing

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. This alternative was developed in response to comments received from the public and tribes during scoping. Alternative 3 is contrary to program direction and mandate to make mineral and energy resources available, but it is supportable due to resource concerns and level of protection needed. This alternative may prevent geothermal development on private land in and adjoining the project area due to federal resource drainage issues.

2.3.3.1 Lands Closed to Leasing

Under Alternative 3, 194,900 acres would be closed to leasing, including nondiscretionary closed lands in the JNRA.

[9] This list originally included deer and elk winter range, but that was removed because none is identified in the project area. Migratory bird nesting areas were removed from the TLs and will be included as a notice to lessee.
[10] No deer fawning areas were identified, so that designation was removed.

2.3.3.2 Lands Available for Leasing

There would be no lands available for leasing in the project area under Alternative 3.

2.3.4 Alternative 4—Development Alternative

Developed to complete the range of alternatives, Alternative 4 incorporates the BLM's information on the RFDS of geothermal resources; therefore, it focuses on the Leasing Interest Unit (i.e., Pending Lease Unit) and the Northern Unit.

2.3.4.1 Lands Closed to Leasing

The Forest Service has determined that certain lands in the project area are excluded from geothermal leasing on the basis of existing laws, regulations (43 CFR, Subpart 3201.11), and executive orders. These non-discretionary closures include approximately 28,900 acres in the JNRA. There would be no discretionary closures under Alternative 4. In total, 28,900 acres would be closed to geothermal leasing.

2.3.4.2 Lands Available for Leasing

Under the proposed action, approximately 139,800 acres of Forest Service lands in the project area would be available for geothermal leasing. This would be subject to existing laws, regulations, formal orders, and stipulations attached to the lease form and to the terms and conditions of the standard lease form.

No Surface Occupancy

NSO stipulations would apply to the following:

- Natural geothermal features, such as hot springs or other surface expressions of geothermal activity, and a one-mile protection zone around them.
- Designated or proposed critical habitat for listed species under the Endangered Species Act (ESA) of 1973 (as amended) if it would adversely modify the habitat. For listed or proposed species without designated habitat, NSO would be implemented to the extent necessary to avoid jeopardy.
- Areas with important cultural and archaeological resources, such as
  - Traditional cultural properties and Native American sacred sites, as identified through consultation
  - Properties listed on or eligible for listing on the NRHP, including National Landmarks and National Register Districts and Sites
  - Additional lands outside the designated boundaries, to the extent necessary to protect values where the setting and integrity are critical to their designation or eligibility
  - Areas that qualify for cultural resource protection, based on Forest Plan criteria
- Water bodies; perennial rivers and streams; riparian areas, wetlands, and playas; 100-year floodplains; and a 500-foot-wide protection zone around them
- Acequias, which are not included in the NHD and will need to be delineated on-site; acequias with OSE-recognized water rights would have a protection zone of 50 feet, measured horizontally from the outer edge of the ditch
- Drinking water sources that are NMOSE recognized and a one-mile protection zone around them

- Developed recreation facilities, special-use permit recreation sites, areas with significant recreation where geothermal development is deemed incompatible, and the following administrative sites
  - San Antonio Creek Recreational Area
  - Seven Springs Recreation Area
  - Paliza Recreation Area
  - Seven Springs Administrative Site
  - Encino Administrative Site
  - Encino Point Administrative Site
  - Cerro Pelado Lookout Administrative Site
- Inventoried roadless areas
- Slopes in excess of 40 percent

Approximately 122,500 acres of Forest Service lands would be available to leasing under Alternative 4, subject to NSO stipulations.

Controlled Surface Use

CSU stipulations would apply to the following areas and site conditions:

- Intermittent streams listed in the NHD and ephemeral drainages delineated by site-specific mapping
- NMOSE-recognized springs and all NMOSE-permitted wells
- Protection of slopes between 30 and 40 percent; this stipulation would be applied to minimize the potential for soil erosion on these slopes
- Soils with severe erosion potential
- Protection of important dispersed recreational areas; this stipulation would be applied to minimize the potential for adverse impacts on recreational values, both motorized and nonmotorized, and the natural settings associated with the recreation
- Viewsheds with a Scenery Management System integrity level of very high and high

Approximately 122,600 acres of Forest Service lands would be available for leasing under Alternative 4, subject to CSU stipulations. Of these lands, approximately 78,200 acres are subject to NSO stipulations.

Timing Limitations

TLs would apply as appropriate to the following areas:

- Mexican spotted owl designated PACs—Drilling and construction would be prohibited between March 1 and August 31.
- Northern goshawk designated post-fledging areas—Drilling and construction would be prohibited between March 1 and September 30.
- Peregrine falcon eyrie nesting areas—Drilling and construction would be prohibited between March 1 and August 15.
- Elk calving areas—Drilling and construction would be prohibited between June 1 and July 31.

Approximately 42,200 acres of Forest Service lands would be available to leasing under Alternative 4, subject to TL stipulations. Of these lands, approximately 36,900 acres are also subject to CSU stipulations, and approximately 41,800 acres are also subject to NSO stipulations.

Standard Lease Terms and Conditions

Under Alternative 4, approximately 3,800 acres would be open to leasing, subject to standard lease terms and conditions; that is, they would not be subject to closures or NSO, CSU, or TL stipulations, as described above.

Notice to Lessee

The notice to lessee of no vegetation clearing between May 15 and July 31 would be applied in migratory bird nesting areas.

2.4 Alternatives Considered but Eliminated from Detailed Study

NEPA requires federal agencies to rigorously explore and objectively evaluate all reasonable alternatives and to briefly discuss the reasons for eliminating any that were not developed in detail (40 CFR, Subpart 1502.14). Through their comments on the proposed action, the public suggested alternative methods for achieving the purpose and need. Some of these alternatives may have been outside the scope of identifying lands as being open or closed to leasing, were duplicative of the alternatives considered in detail, or were determined to be components that would cause unnecessary environmental harm. These suggested alternatives were considered but dismissed from detailed consideration for the reasons summarized below.

2.4.1 Reduced Project Area

Under a reduced project area alternative, the SFNF would evaluate future geothermal leasing only in the 46,000 acres where the BLM has received expressions of interest in leasing. This alternative was considered but eliminated from detailed analysis because it fails to address the potential for future lease nominations on other lands with significant geothermal potential on the SFNF. In these areas, geothermal lease applications and nominations would be evaluated on a case-by-case basis under separate NEPA analyses. This could yield delays and inefficient consideration of future project planning.

2.4.2 Enlarged Project Area

Under an enlarged project area alternative, the SFNF would evaluate future geothermal leasing on additional lands within the SFNF (beyond the currently defined project area boundary of 194,000 acres). This would include lands east of the project area boundary. This alternative was considered but eliminated from detailed analysis due to limited geothermal potential and existing constraints on geothermal development potential.

2.4.3 Alternative with Stipulations and No Exceptions, Waivers, or Modifications

Under this alternative, geothermal stipulations would be applied, as described under the proposed action alternative; however, no lease exceptions, waivers, or modifications would be granted. This alternative was considered but eliminated from detailed analysis because some stipulations are based on resources that are not permanent, fixed geographic points, or polygons and may change over time. For example, an NSO stipulation would be applied to designated critical habitat for species listed under the ESA, and a TL stipulation would be applied to elk calving areas. Species may become delisted over time, or elk calving areas may change, based on forage availability. Non-consent for resources that are dynamic, such as those examples provided above, would not allow for adaptive management when circumstances change.

2.4.4 Compensatory Off-Site Mitigation

Under this alternative, the Forest Service would require compensatory off-site mitigation for unavoidable impacts that may result from geothermal leasing. This alternative was considered but eliminated from detailed analysis because the extent and level of detail regarding adverse or unavoidable impacts for specific geothermal land use authorizations is unknown at this time.

2.4.5 Wilderness Protection

Under the wilderness protection alternative, the SFNF would apply the stipulations described under the proposed action; however, IRAs and lands meeting wilderness planning criteria (FSH 1909.12, Land Management Planning Handbook, Chapter 70 – Wilderness Evaluation), would be closed to leasing. This alternative was considered but eliminated from detailed analysis because evaluating lands with wilderness characteristics is beyond the scope of this project.

2.5 Reasonably Foreseeable Development Scenario

In 2015, the BLM prepared an RFDS for the SFNF geothermal leasing project (BLM 2015) for the time frame of 2016 through 2031. The RFDS is a best professional estimate of what may occur if lands in the project area were leased. It is based on the assumption that all potentially productive areas can be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation, or executive order. It is not intended to be a maximum development scenario; however, it is biased toward the higher end of expected development. The RFDS for geothermal resource use involves three sequential phases: (1) exploration, (2) development drilling and utilization, and (3) final plugging and reclamation. Activities and acres of surface disturbance associated with each phase are summarized below.

2.5.1 Exploration

As described in detail within the RFDS, activities associated with exploration are geochemical surveys, geologic mapping, geophysical surveys, exploration drilling, and temperature-gradient drilling. **Table 2-2**, below, provides a description of expected disturbance in the project area from the exploration phase of geothermal development.

2.5.2 Development Drilling and Utilization

Drilling and utilization involves full-diameter well drilling, power plant construction, power plant utilization, and repairs and maintenance. **Table 2-3**, below, provides a description of the expected disturbance in the project area from the development drilling and utilization phase of geothermal energy use.

Table 2-2. Summary of Surface Disturbance from Exploration Activities

Activity	Amount Expected Over Life of Plan	Amount of Disturbance per Unit (Acres)	Disturbance over Project Area for Life of Plan (15 Years) (Acres)
Temperature-gradient wells[11]	15	0.25	3.75
Slim wells[12], 0.2 wells per lease	5	2.8	14
Exploration roads	10 miles of road widened by 8 feet	N/A	9.7
Total			**27.45**

Source: BLM 2015

Table 2-3. Summary of Surface Disturbance from Drilling and Utilization

Activity	Amount Expected over Life of Plan	Amount of Disturbance (Acres)	Disturbance over Project Area for Life of Plan (15 Years) (Acres)
Production and/or injection wells	30	5 per well	150
Transmission lines	A maximum of 14 miles, at a width of 200 feet	N/A	339
Pipelines	A maximum of 7 miles per plant, with a width of 25 feet	21.2 per plant	106
Roads	10 miles of road widened 2 feet	N/A	2.42
Power plant and ancillary facilities	5 power plants	10 per power plant	50
Total			**647.42**

Source: BLM 2015

2.5.3 Plugging and Final Reclamation

The final stage of geothermal operations is abandonment when exploration is unsuccessful or after production ceases. Certain facilities may be abandoned before all operations are ready for closure, and interim reclamation, such as revegetating the shoulders and ditches of access roads, may occur immediately following construction. The RFDS expects that 40 percent of the well pad area would be subject to interim reclamation. The physical footprint of the well pads would not undergo interim reclamation; however, interim reclamation would occur in the area surrounding the well pads.

[11] Temperature-gradient wells enable the investigation of temperatures at shallow depths in and around a geothermal system. Initial well diameters are typically 8 to 10 inches (BLM 2015).
[12] Slim wells are 3 to 6 inches in diameter and are used to recover core, take water samples, and measure thermal and fluid flow properties (BLM 2015).

2.6 Comparison of Alternatives

This section provides a summary of the effects of implementing each alternative. Information in the table is focused on activities and effects where different levels of effects or outputs can be distinguished quantitatively or qualitatively among alternatives.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Land use, recreation, and special designations	The JNRA (approximately 28,900 acres) would remain closed to geothermal leasing. No direct impacts would occur in this area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations.	Impacts would be minimized by implementing CSUs, NSOs, and TLs. These would be designed to protect existing land uses, recreation areas, and special designation areas. Compared with the Alternative 1, Alternative 2 provides specific guidance to ensure an SFNF-wide approach is adopted and that land use, recreation, and special designation areas are considered across all users of the SFNF.	There would be no direct or indirect impacts on land use on 168,600 acres of the SFNF project area.	Of the alternatives that include geothermal leasing, Alternative 4 would have fewer closed acres, fewer acres under NSO, more acres under CSU, fewer TLs, fewer stipulations, and more waivers and modifications. Because of the greater access to SFNF lands and fewer restrictions, Alternative 4 would have a greater impact on the broad spectrum of land uses, recreation areas, and special designation areas on the SFNF.
Geologic resources	The SFNF would process leases on a case-by-case basis. Geothermal development projected under this alternative could slightly increase the likelihood of seismic activity in and around the project area, particularly if enhanced geothermal systems are used. This would require further analysis, if proposed as part of a geothermal development project.	Impacts would be the same as those described under Alternative 1.	There would be no direct or indirect impacts on geologic resources in the project area.	Impacts would be the same as those under Alternative 1.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	Geothermal development may also slightly increase the risk of subsidence in the project area. Impacts on volcanic activity or release of radioactive material are not expected to result from the projected geothermal development.			
Energy and mineral resources	Impacts on energy and mineral resources would be evaluated on a case-by-case basis under separate NEPA analyses. While additional roads and transmission lines could encourage additional energy and mineral development, other limitations associated with those resources would still prevent their development.	Impacts would be the same as those described under Alternative 1.	All Forest Service lands in the project area would be closed to geothermal leasing. There would be no construction of transmission lines or development of roads specifically for geothermal energy development. There would be no impacts on non-geothermal energy and mineral resources.	Impacts would be the same as those described under Alternative 1.
Paleontological resources	Geothermal lease stipulations and closures would not be specifically implemented on paleontological resources outside of the JNRA; however, all geothermal lease applications and nominations would be subject to the standards and guidelines outlined in the Forest Plan and subsequent environmental analysis. Surface disturbance related to geothermal development could impact an unknown quantity of fossils that may	Impacts would be similar to those described under Alternative 1. Closures and stipulations would not be specifically implemented for paleontological resources; however, closures and stipulations for other resources would inadvertently protect geologic units with likely fossil occurrences. The potential for geothermal development to impact sensitive geologic units is low, considering geothermal leasing closures, stipulations, and BMPs.	There would be no direct or indirect impacts on paleontological resources under Alternative 3.	Impacts under Alternative 4 on paleontological resources would be similar to those described under Alternative 2; however, fewer acres in areas with likely fossil occurrence would be subject to NSO stipulations and closures, and more acres would be subject to CSU stipulations. The potential for geothermal development to impact sensitive geologic units is low, considering geothermal leasing closures, stipulations, and BMPs.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	occur on or underneath the surface in areas containing paleontologically sensitive geologic units.			
Soil resources	Impacts would be assessed on a case-by-case basis. Geothermal development could result in physical disturbance, compaction, changes to erosion patterns, and loss of soil productivity. Impacts could result from the development of roads and facilities and geothermal projects, including construction and operation.	Impacts from geothermal exploration and development would be similar to those described under Alternative 1; however, they would be restricted in location by administrative withdrawals and stipulations. NSO stipulations would limit erosion on soils with severe erosion hazards and steep slopes, but they would exclude potential impacts from powerline and road construction and road use.	There would be no direct impacts on soils under Alternative 3. However, there would be indirect impacts on soil resources because the project area would be closed to geothermal leasing for the foreseeable future. Over time, there would be less soil disturbance than expected under the current Forest Plan.	Impacts from geothermal exploration and development would be similar to those described under Alternative 2; however, they would have more potential for impacts on slopes between 30 and 40 percent and in areas with moderately high to high runoff potential, due to a reduction in stipulations.
Water resources	Impacts would be assessed on a case-by-case basis. Geothermal development could result in contamination, altered groundwater flow paths or pressurization, and changes in water temperature. Exploration, development, and operation could result in increased sediment and turbidity in surface water and contamination of surface water or groundwater by accidental release of chemicals or waste. Water	Impacts from geothermal exploration and development would be similar to those described under Alternative 1; however, they would be restricted in location by administrative withdrawals and stipulations. NSO stipulations would reduce the potential for direct impacts on many hydrologic features. They would also limit erosion on soils with severe erosion hazard and steep slopes. This would reduce the potential for	There would be no impacts on watersheds or groundwater resources under Alternative 3. However, there would be indirect impacts on water resources. Because the project area would be closed to geothermal leasing for the foreseeable future, over time, there would be less surface disturbance than expected under the current Forest Plan, and less potential for changes to surface or subsurface water resources.	Impacts under Alternative 4 would be similar to those described under Alternative 2. However, there would be no discretionary closures under Alternative 4, and there would be reduced protection of specific areas from implementing less restrictive lease stipulations. Water and geothermal fluids may be lost when reinjected into the formation or through accidental spills or releases.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	and geothermal fluids may be lost when reinjected into the formation or through accidental spills or releases.	sedimentation into streams but would exclude potential impacts from road and powerline construction, and road use. Water and geothermal fluids may be lost when reinjected into the formation or through accidental spills or releases.		
Air quality and air quality-related values	There would be temporary and short-term impacts on air quality during exploration, development, and utilization from fugitive dust and equipment and vehicle exhaust. Impacts would be minimized through BMPs applied at the permit level. Impacts from hydrogen sulfide release, if present in the geothermal resource, would be avoided with blowout prevention equipment and through monitoring and abatement, if required by New Mexico Environment Department (NMED) during air permitting. Long-term emissions from operating the binary-cycle plants would be low because they are closed-loop systems that are designed to not emit pollutants. Because the plants would be air cooled, they	The RFDS would be the same as described under Alternative 1; therefore, impacts related to the overall levels of emissions would be the same. The constraints in areas open to leasing may alter the locations where geothermal development would occur. More areas would be constrained than under Alternative 1, so activities under Alternative 2 could occur within a smaller area. Because geothermal plants would be spaced by 1 mile or more, the overall direct and indirect impacts would be the same as under Alternative 1.	There would be no geothermal development; therefore, no direct or indirect effects on air quality or air quality related values (AQRVs) would occur.	Direct and indirect impacts on air quality and AQRVs would be the same as described for Alternative 1.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	would not emit steam plumes and, therefore, would not affect visibility in Class I areas. The plants would not emit hydrogen sulfide, if present in the resource, during normal operations; therefore, operations would not emit nuisance odors. All activities must comply with the Clean Air Act and applicable state air quality regulations.			
Vegetation	The JNRA would remain closed to geothermal leasing. No direct impacts on vegetation would occur in this area. Elsewhere, geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. Direct impacts (vegetation removal and vegetation communities alteration) and indirect impacts (introduction or spread of invasive species) may occur. Up to 765 acres may be disturbed in vegetation communities by developing well pads,	The RFDS would be the same as described under Alternative 1; therefore, impacts related to the overall levels of disturbance would be the same. Compared to Alternative 1, an additional 3,100 acres would be closed to geothermal leasing. Impacts would be minimized by implementing CSUs, NSOs, and TLs. These would be designed to protect vulnerable and important vegetation communities. Up to 765 acres may be disturbed in vegetation communities by developing well pads, roadways, transmission corridors, and other geothermal facilities.	There would be no geothermal development; therefore, no direct or indirect effects on vegetation would occur.	The RFDS would be the same as described under Alternative 1; therefore, impacts related to the overall levels of disturbance would be the same. Impacts would be similar to Alternative 2, except that fewer acres would be closed to geothermal leasing and fewer acres would be subject to NSO stipulations. Intermittent streams and slopes with severe erosion potential would be subject to CSU stipulations. Impacts on riparian vegetation communities may be more severe than under Alternative 2, because there would be less restrictive geothermal leasing stipulations in these areas, compared with Alternative 2.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	roadways, transmission corridors, and other geothermal facilities.			
Fish and wildlife	The JNRA would remain closed to geothermal leasing, and no direct impacts on fish and wildlife would occur in this area. Elsewhere, geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. Geothermal leasing stipulations and closures specific to fish and wildlife would not be implemented under this alternative; however, any geothermal lease applications and nominations would be subject to standards and guidelines outlined in the forest plan and environmental analysis.	The RFDS would be the same as described under Alternative 1; therefore, impacts related to the overall levels of disturbance would be the same. Impacts on fisheries and aquatic biota could occur from erosion and sedimentation into rivers and streams; however, geothermal leasing stipulations on steep slopes and erosive soils would mitigate these effects, and impacts are unlikely to result in a substantial population change. Impacts on wildlife could occur though habitat alteration, removal, reduction, or fragmentation. Implementing TLs would limit impacts on seasonally important wildlife habitat. Impacts would not lead to a substantial population change for any wildlife species.	There would be no geothermal development; therefore, no direct or indirect effects on fish and wildlife would occur.	The RFDS would be the same as described under Alternative 1; therefore, impacts from the overall levels of disturbance would be the same. Direct and indirect impacts on fish and wildlife would be similar to those described under Alternative 2; however, there would be a greater likelihood of increased sedimentation flowing into perennial streams, which reduce the quality of habitat for sediment intolerant aquatic species.
Threatened and endangered species and special status species	The JNRA would remain closed to geothermal leasing, and no direct impacts on threatened or endangered species or special status	The RFDS would be the same as described under Alternative 1; therefore, impacts from the overall levels of disturbance would be the same.	There would be no geothermal development; therefore, no direct or indirect effects on threatened and endangered species and	The RFDS would be the same as described under Alternative 1; therefore, impacts related to the overall levels of disturbance would be

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	species would occur in this area. Elsewhere, geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations. The types of effects could include habitat disturbance or alteration, noise disturbance, injury or mortality, exposure to contaminants, and interference with behavioral activities. All actions must comply with the ESA.	Alternative 2 would not result in adverse impacts on threatened or endangered species, and would not lead to a trend toward federal listing of non-federally listed special status species. All actions must comply with the ESA.	special status species would occur.	the same. Impacts would be similar to Alternative 2; however, the potential disturbance on intermittent streams could lead to increased sedimentation flowing into perennial streams and could have an impact on species that are sediment intolerant, such as Rio Grande sucker, Rio Grande chub, RGCT, and other cold water fish species. All actions must comply with the ESA.
Livestock grazing	The JNRA would remain closed to geothermal leasing. Within those 28,900 acres, there would be no disturbance to livestock or livestock management. Impacts identified in the 2008 geothermal PEIS could occur on allotments outside of the JNRA on a case-by-case basis.	In addition to portions of allotments closed to geothermal development that fall within the JNRA, Alternative 2 closes other areas based on special circumstances, and impacts would be less than under Alternative 1. Indirect impacts on grazing allotments outside of the JNRA and other closure areas would be a reduction in forage, a possible reduction in animal unit months (AUMs), and harassment of livestock.	There would be no direct or indirect impacts on livestock or livestock operations from geothermal leasing.	Indirect impacts would be the same as those described for Alternative 1.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Cultural resources	Because there would be site-specific analysis, potential impacts on cultural resources and their settings could be avoided or reduced, but there would be no additional established stipulations for surface use that may incidentally reduce impact potential on cultural resources. Current closures to leasing in the JNRA would continue.	The potential for impacts on cultural resources would be reduced by additional closures and stipulations. Stipulations for other surface uses may also incidentally reduce the impact potential on cultural resources. NSO stipulations would be implemented for areas with important cultural resources and their settings, including archaeological resources, traditional cultural properties, sacred sites, and NRHP-eligible and listed properties. There are 1,567 known sites that would be included in land with NSO stipulations under this alternative.	Implementing discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing would result in no leasing and no subsequent development. There would be no impacts on cultural resources and their settings.	The potential for impacts on cultural resources would be reduced by stipulations, but there would be no new closures. Stipulations for other surface uses may also incidentally reduce the impact potential on cultural resources. NSO stipulations would be implemented for areas with important cultural resources and their settings, including archaeological resources, traditional cultural properties, sacred sites, and NRHP-eligible and listed properties. There are 1,522 known sites that would be included in land with NSO stipulations under this alternative.
Tribal interests and traditional cultural resources	Potential direct and indirect impacts from subsequent geothermal development could disturb landscapes and locations associated with religious beliefs or cultural uses. Because there would be site-specific analysis and consultation, potential impacts could be avoided or reduced, but there would be no additional established stipulations for surface use	There would be new closures and NSO stipulations for traditional cultural properties and Native American sacred sites, as identified through consultation and site-specific consideration of impacts on tribal interests and traditional cultural resources and uses and their settings for each phase of geothermal development. The potential for impact from subsequent geothermal	The SFNF would amend the forest plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. Because there would be no leasing and no subsequent development, no new impacts are anticipated.	There would be NSO stipulations for traditional cultural properties and Native American sacred sites, as identified through consultation and site-specific consideration of impacts and consultation for each phase of geothermal development. The potential for impact from subsequent geothermal development would be reduced; however, tribes may consider the disturbance of

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	that may incidentally reduce impact potential on tribal interests and traditional cultural resources and uses. Tribes may consider the disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized.	development would be reduced; however, tribes may consider the disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. Additional habitat and visual protections may incidentally reduce the impact potential on traditional cultural resources and resource uses, cultural landscapes, and their settings.		the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. Additional habitat and visual protections may incidentally reduce the impact potential on traditional cultural resources and resource uses, cultural landscapes, and their settings.
Visual resources	The JNRA would remain closed to geothermal leasing. Visual resources would be protected in this area. Elsewhere, visual resources could be impacted because of the lack of stipulations. The visual variety of the landscape in areas with very high or high scenic integrity would make hiding geothermal development activities easier than in areas with moderate, low, or very low scenic integrity. However, areas with existing development may be able to absorb new development without much change in the overall landscape.	The JNRA would remain closed to geothermal leasing, and an additional 10,400 acres would also be closed; impacts would be the same as under Alternative 1 but over a larger area. In areas restricted by NSO stipulations, visual resources would be preserved in the same way that areas closed to leasing would be protected. Areas restricted by CSU stipulations would see reduced impacts on visual resources. These landscapes generally have diverse topography, colors, and vegetation, which can be used to screen development from casual observers. Finally, areas not subject to NSO or CSU stipulations	There would be no leasing, so no impacts on visual resources from geothermal exploration or development.	Impacts would be similar to Alternative 2, except that fewer acres would be closed to geothermal leasing and fewer acres would be subject to NSO stipulations. Therefore, more acres would be subject to possible impacts on visual resources. CSU stipulations on most of the area not closed to leasing would offer some protection, but any development could impact visual resources. More acres would be open to leasing not subject to NSO or CSU stipulations than under Alternative 2. Impacts would be the same but would occur over a larger area.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
		have the greatest risk of impacts. These areas have either moderate or low scenic integrity.		
Social interests, economics, and environmental justice	Impacts would occur on a case-by-case basis but would include temporary and long-term job creation, new federal royalty payments and taxable incomes, and retained recreation and tourism revenues in the long term.	Overall impacts are the same as Alternative 1, but economic impacts could be less regionally dispersed due to NSO, CSU, and TL stipulations.	There would be no lands available for leasing in the project area and no impacts on socioeconomics from geothermal development.	Overall impacts are the same as Alternative 1, but economic impacts could be less regionally dispersed due to NSO, CSU, and TL stipulations.
Health and safety	Impacts would continue to occur on a case-by-case basis, and measures to minimize impacts on health and safety would be considered in separate NEPA analyses. There would be a risk of human-caused fire from geothermal development. However, because power line rights-of-way would be cleared of trees, the risk of wildfire associated with trees causing downed power lines would be minor.	The nature and character of impacts would be similar to those described for Common Impacts Associated with Geothermal Development. BMPs included in approved use authorizations would protect public health and safety by minimizing risks to workers and the public. The risk of wildfire associated with downed power lines would be the same as under Alternative 1.	There would be no lands available for leasing in the project area and no impacts on health and safety from geothermal activities.	Impacts would be the same as those described under Alternative 2, because the same level of disturbance, the same number of wells, and the same number of power plants are expected.
Noise	Impacts would continue to occur on a case-by-case basis, and measures to minimize noise impacts would be considered in separate NEPA analyses.	Due to the highly rural and unpopulated nature of lands in the project area, it is unlikely that any sensitive receptors would experience noise levels approaching the 65 A-weighted decibels (dBA) limit specified in BLM regulations.	There would be no lands available for leasing in the project area and no noise impacts from geothermal activities.	Impacts would be the same as those described under Alternative 2, because the same level of disturbance, the same number of wells, and the same number of power plants are expected.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Transportation and access	Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations.	Alternative 2 would result in greater limitations for siting geothermal infrastructure. This could result in more concentrated areas of development, resulting in fewer impacts on transportation and access within an NSO boundary, but a potentially higher concentration of visual and noise impacts for travelers in areas outside of an NSO boundary. It may also concentrate traffic issues, although any future action would have to comply with the Forest Plan and the Travel Management Plan and be studied under a site-specific NEPA analysis.	There would be no direct or indirect impacts on the transportation network or access over the 168,600 acres of the SFNF project area.	Of the alternatives that include geothermal leasing, Alternative 4 would have fewer closed acres, fewer acres under NSO, more acres under CSU, fewer TLs, fewer stipulations, and more waivers and modifications. Because of the greater access to SFNF lands and fewer overall restrictions, Alternative 4 may have a greater impact on transportation and access on the SFNF.
Climate change	There would be no direct impacts. Indirect impacts are from GHG emissions during all project phases from the following: fuels combustion by equipment and vehicles, the release of carbon dioxide in the geothermal resource, and the removal of vegetation and disturbance of soils on 760 total acres. BMPs that reduce equipment and vehicle exhaust emissions to minimize impacts on air quality would also reduce	Impacts would be the same as those described for Alternative 1.	There would be no geothermal development and no emissions of GHGs. If there is no geothermal power plant development, there could be an indirect negative impact on climate change if power from conventional fossil fuel sources of electricity were developed in place of geothermal development.	Impacts would be the same as those described for Alternative 1.

Table 2-4. Comparison of Alternatives

Resource or Use	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	GHG emissions. GHGs emissions from plant operation are from commute traffic, maintenance traffic, truck deliveries, and potential releases of carbon dioxide during well maintenance. GHG emissions would be below the 25,000 metric tons per year reporting limit under the Greenhouse Gas Monitoring Rule. Geothermal power plant development could have an indirect beneficial impact if power produced by the geothermal plant were to displace electricity generated by conventional fossil fuel sources of electricity.			

Chapter 3. Affected Environment and Environmental Consequences

3.1 Introduction

This chapter describes the affected environment and environmental consequences for resources and resource uses. The affected environment discussion includes a description of the biological, physical, and socioeconomic characteristics, including human uses, that could be affected by any future actions. Information from broad-scale assessments was used to help set the context for the project area. The information and direction for NFS lands has been further broken down into fine-scale assessments and information, where possible.

The environmental consequences discussion analyzes direct, indirect, and cumulative impacts expected to occur by implementing any future actions (including any decisions to lease or develop geothermal resources) that may be taken, consistent with the four alternatives: Alternative 1, the No Action Alternative; Alternative 2, the Proposed Action; Alternative 3, No Leasing; and Alternative 4, the Development Alternative. The scope of the analysis is commensurate with the detail of the alternatives and the availability of data. Current conditions of the project area, as described under the affected environment sections, provide the baseline for assessing impacts.

3.2 Methods and Assumptions Common to the Analysis of Impacts

Consenting to issue a geothermal lease has no direct impact on the environment; however, it is a commitment of the resource for potential future exploration, drilling operations and development, utilization, and reclamation and abandonment, which are subject to environmental review and permits. Therefore, this EIS analyzes the potential impacts of the various stages that may follow a leasing decision, along with the potential cumulative impacts throughout the entire project area.

The method for the following impact assessment conforms to the guidance found in the following sections of the CEQ regulations for implementing NEPA:

- 40 CFR, Subpart 1502.24 (Methodology and Scientific Accuracy)
- 40 CFR, Subpart 1508.7 (Cumulative Impact)
- 40 CFR, Subpart 1508.8 (Impacts)

CEQ regulations require that agencies “rigorously explore and objectively evaluate” the impact of all alternatives.

The alternatives described in **Chapter 2** do not specifically propose developing a geothermal resource. For this reason, the analysis relies on the RFDS, which projects future geothermal leasing and development on NFS lands in the SFNF geothermal leasing project area from 2016 through 2031 (15 years) based on best professional judgment. The RFDS is based on the assumption that all potentially productive areas can be open under standard lease terms and conditions, except those designated as closed to leasing by law, regulation, or executive order. Therefore, it does not consider any allocations (e.g., NSO, CSU, or TL stipulations) prescribed under any of the alternatives when projecting future geothermal leasing and development. The

RFDS is not intended to be a "maximum-development" scenario; however, it is biased toward the higher end of expected development.

It is important to note that the magnitude and extent of impacts on any resource or resource use will vary, depending on the amount of land apportioned for each lease. A lease can range in size from 640 acres up to 5,120 acres.

A consent to lease lands, in and of itself, does not cause any direct impacts, as defined by the CEQ regulations, which state that such impacts "are caused by the action and occur at the same time and place" (40 CFR, Subpart 1508.8[a]). Before any ground disturbance or other future actions that would occur consistent with implementing the plan, further decision-making would be required. This decision-making must take place before any future actions. It would take into consideration a wide variety of factors, including policy initiatives about timing of actions, whether any applications are submitted, whether funding is available, and compliance with other authorities and policies.

The regulations governing geothermal leasing and development provide for several decision stages before any ground-disturbing activities take place and may include further compliance with applicable authorities during these decision stages. Prior to ground disturbance, additional site-specific analysis would be required as described in Chapter 1. Under this regulatory scheme, the BLM receives and approves an application for a permit to drill or other authorization with specific information about a particular project. Until then, the impacts of actual development that might follow lease issuance are speculative. This is because so much is unknown as to location, scope, scale, and timing of that development. At each decision stage, the BLM retains the authority to approve, deny, or approve subject to conditions any permit, based on compliance with applicable authorities and policies. Therefore, the analysis of the impacts of development in this EIS reflects a more general, programmatic approach.

Any future development of geothermal resources would result in impacts. It is reasonable, therefore, to foresee what on-the-ground impacts would occur if the Forest Service were to consent to leasing and the BLM were to issue geothermal leases. However, those impacts would not occur until some point in the future and following several decision stages. Because of this, the following analysis focuses primarily on both direct and indirect impacts of future development of geothermal resources. It is based on the foreseeable on-the ground actions, taking into consideration the stipulations, BMPs, and procedures outlined in the 2008 Geothermal PEIS. These impacts cannot be analyzed site specifically, but they can be analyzed in general terms for the leasing area, based on the RFDS outlined in **Chapter 2**.

The following assumptions from the RFDS were applied for the analysis in Chapter 3:

- A total of 25 leases would be issued during the 15-year RFDS time frame.
- Five 25-megawatt binary power plants would be developed on leases in the project area, with separations of a mile or more between plants.
- The total acres of surface disturbance associated with geothermal exploration is anticipated to be 27.
- The total acres of surface disturbance associated with development drilling and utilization is 647. This includes disturbance associated with developing wells, transmission lines, pipelines, roads, power plants, and ancillary facilities.
- Based on existing temperature gradient data, binary cycle power plants are most likely to be constructed in the project area. These plants operate at lower temperatures than flash steam

plants or dry steam plants. Therefore, this analysis does not analyze the potential impacts of flash steam or dry steam geothermal power plants.

3.3 Cumulative Actions for Cumulative Impacts Analysis

The CEQ regulations state that the cumulative impact analysis should include the anticipated impacts on the environment resulting from "the incremental impact of [an] action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time" (40 CFR, Subpart 1508.7).

Sections 3.3.1 through **3.3.4** describe the processes for assessing cumulative impacts, the time frame of the cumulative projects, and reasonably foreseeable future actions for the cumulative impact assessment. Each resource or resource use section includes a cumulative impact assessment.

3.3.1 Process for Assessing Cumulative Impacts

The cumulative impact analysis for each resource or resource use builds on the analyses of the direct and indirect impacts of anticipated future actions to be taken, consistent with the project alternatives. In addition, the cumulative impact analysis considers other past, present, and reasonably foreseeable future actions and their impacts on natural resources, ecosystems, and human uses in the project area.

3.3.2 Regions of Influence

To determine which other actions should be included in a cumulative impacts analysis, the region of influence for each resource must first be defined. These regions should not be limited to only the geographic areas of resources addressed by the project, but they should also take into account the distances that cumulative impacts may travel and the regional characteristics of the affected resources.

Because this EIS addresses the consent to lease NFS lands at a programmatic level, the region of influence for each resource evaluated by the cumulative impacts analysis is the project area, unless otherwise noted.

3.3.3 Time Frame of the Cumulative Projects

The time frame of the cumulative impact analysis incorporates the sum of the impacts of anticipated future actions consistent with implementing an alternative, in combination with other past, present, and future actions. This is because impacts may accumulate or develop over time. The future actions described in this analysis are those that are "reasonably foreseeable"; that is, they are ongoing (and will continue into the future), are funded for future implementation, or are included in firm near-term plans. The reasonably foreseeable time frame for future actions evaluated in this cumulative analysis is 20 years from the consent to geothermal leasing. While it is difficult to project reasonably foreseeable future actions (or trends) beyond a 20-year time frame, the impacts identified in the cumulative impacts analysis will likely continue beyond the 20-year horizon.

3.3.4 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions are projects, activities, or trends that could impact human and environmental receptors in the defined regions of influence (**Section 3.3.2**) and in the defined time frames (**Section 3.3.3**).

Table 3-1. Reasonably Foreseeable Future Actions

Project Name	General Location	Project Description
Vegetation Management		
Southwest Jemez Mountains Landscape Restoration Project	Middle Jemez River Watershed	Ecological restoration of up to 110,000 acres in the greater Southwest Jemez Mountains over 10 years.
Supplement to the Final EIS for Invasive Plant Control Project EIS	Carson and Santa Fe National Forests	Updates information contained in the Forest Service's Final Environmental Impact Statement for the Invasive Plant Control Project, published September 2005.
Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project	Santa Fe National Forest, Espanola Ranger District	Thinning in a stand of pinyon-juniper of 165 acres to improve the health and fire resilience of the stand. This should result in increased pinyon nut production for birds and other wildlife. This project has been postponed.
Water Resources		
Pueblo of Jemez Red Rocks Dam Repair	Pueblo of Jemez	The project area is on the east side of New Mexico State Highway 4 (NM 4), in an unnamed ephemeral stream channel and arroyo. This arroyo flows west into the Jemez River, which is less than 0.4 mile downstream. During the federal disaster declared by the president and designated as Federal Emergency Management Agency (FEMA) Number 4152-DR-NM, a major storm and subsequent high water flows eroded the containment berm at Red Rocks Dam. This caused a breach and failure of the stormwater detention facility. This facility provides flood protection for downstream road and irrigation infrastructure at the Pueblo of Jemez. As such, the purpose of the proposed project is to repair the stormwater detention facility and protect downstream infrastructure.
Pueblo of Jemez Owl Springs Bridge Sediment Removal Project	Pueblo of Jemez	The Natural Resources Department of Jemez Pueblo is proposing to use a track hoe for removing the sedimentation; it will be operated from the banks of the Jemez River.
Valle Seco Wetland Restoration Project	Valles Caldera	The proposal is to restore severely eroded emergent wetlands in the watershed of Sulphur Creek in the Valles Caldera National Preserve (VCNP), Jemez Springs. The project will construct 54 rock and earthen structures along five headwater tributaries (19,580 feet) and 3,600 feet of the main channel. The project proponent will build 25 plug and pond structures, sod dams, one-rock dams, a worm ditch, and contour swales.

Table 3-1. Reasonably Foreseeable Future Actions

Project Name	General Location	Project Description
Abiquiu Land Grant Waterline Replacement Project	Santa Fe National Forest, Espanola Ranger District	In 1967, the Merced de Abiquiu (Land Grant) installed a water collection gallery and water line on NFS lands in order to provide water for livestock. This facility is at the end of its life, and the proposal is to replace it.
McKinney County Dam	Santa Fe National Forest, Jemez Ranger District	Remove McKinney Dam and replace it with a fish barrier. This project is on hold.
Energy and Mineral Resources		
Valles Caldera: Nomination under the Geothermal Steam Act	Valles Caldera National Preserve	The NPS is in the process of listing the Valles Caldera as a significant geothermal feature under the Geothermal Steam Act of 1970 (30 USC, Section 1019). If it were determined by the BLM, in consultation with the NPS, that geothermal operations were reasonably likely to result in a significant adverse impact on such a feature, then the BLM would decline to issue the lease. The BLM or Forest Service, in consultation with the NPS, would include stipulations to protect any significant thermal features of a National Park System unit that could be adversely affected by geothermal development. These stipulations would be added, if necessary, if the lease or permit were issued, extended, renewed, or modified (43 CFR, Subpart 3201.10[b]).
South Pit Pumice Mine Expansion	Santa Fe National Forest, Jemez Ranger District	Approval of a 10-year-plan of operations for a pumice mine of approximately 48 acres next to a recently reclaimed 9-acre pumice mine.
Duran 2010 Pumice Mine	South of Cerro del Pino, Jemez Ranger District, SFNF	Develop an open-pit pumice mine south of Cerro del Pino.
Threatened, Endangered, and Special Status Species		
New Mexico Meadow Jumping Mouse Critical Habitat Protection Project (EA)	Jemez Ranger District, SFNF	Protection and improvement of habitat conditions for the New Mexico Meadow Jumping Mouse.

Source: Forest Service GIS 2015

3.4 Land Use, Recreation, and Special Designations

3.4.1 Affected Environment

This section focuses on the current management and use in project area for the SFNF.

Three resource classes are described and analyzed below: land use, recreation, and special designations. National Scenic and Historic Trails are covered as a subsection under special designations.

3.4.1.1 Land Use

The National Forest Management Act of 1976 requires the Secretary of Agriculture to assess NFS lands, to develop a management program based on multiple-use and sustained-yield principles, and to implement a resource management plan for each unit of the NFS. The primary statutes that authorize the disposal of renewable resources on NFS lands are the Organic Administration Act, Multiple-Use Sustained-Yield Act, and the Bankhead-Jones Farm Tenant Act.

The SFNF operates under the direction of the Forest Plan (Forest Service 1987). In accordance with the Geothermal Steam Act of 1970 (30 USC, Section 1019), the BLM administers geothermal leasing on NFS lands. It does this with the concurrence of the Forest Service, which is mandated by national policies to administer lands under the concept of multiple uses, while protecting the long-term health of the land.

Land Use Authorizations

Land use authorizations include various agreements to use Forest Service land, such as ROW grants, road use agreements, and associated temporary use permits. Land use authorizations are issued for a variety of purposes, both short term and long term. Short-term uses include agricultural leases and other uses involving minimal land improvements or disturbances. Long-term uses include right-of-way grants for power lines, highways, roads, pipelines, fiber-optic cables, communication sites, electric power generation sites, and irrigation canals or acequias.

Rights-of-way and Utility Corridors

A ROW grant is an authorization to use a specific piece of public land for a certain project, such as roads, pipelines, transmission lines, and fiber-optic lines. The grant authorizes rights and privileges for a specific use of the land for a specific period of time. Generally, a Forest Service ROW is granted for the life of the project and remains in impact unless terminated by mutual agreement or one agency giving the other 90 days prior written notice.

Special Use Permits and Leases

A lease is an authorization to possess and use public land for a fixed period. A lease is issued when there is going to be substantial construction, development, and improvement, and there is an investment of large amounts of capital that would be amortized over time. Special use permits are authorized when uses of public lands would be short term and involve little or no land improvement, construction, or investment. Special use permits and leases are subject to process and monitoring fees and a fair-market rental value.

Withdrawals

A land withdrawal is a real estate management tool to implement resource management planning prescriptions or to transfer administrative jurisdiction from one federal agency to another. A withdrawal creates a title encumbrance on the land, thereby restricting an agency’s ability to manage its lands under multiple use management principles. The restrictions generally segregate the lands from some or all the public land laws and some or all of the mining and mineral leasing laws for a specific period, generally 20 years for post-FLPMA withdrawals. Withdrawn land can be closed to mining, mineral leasing, or mineral material disposal.

SFNF Project Area: Land Use

The SFNF project area covers approximately 194,900 acres and is in the northwest-central portion of New Mexico, including Rio Arriba and Sandoval Counties. Property adjacent to the project area is as follows:

- Lands administered by the Taos Field Office of the BLM, LANL, and DOE
- Bandelier National Monument and Valles Caldera National Preserve (VCNP) administered by the NPS
- State and municipal lands
- Jemez Pueblo lands administered by the Pueblo and Bureau of Indian Affairs
- Private lands

There are no major population centers in the project area. Nearby towns are Jemez Springs, Jemez Pueblo, Ponderosa, Cuba, Los Alamos, and other small towns and villages. Ranger Districts on the SFNF are Coyote, Cuba, Espanola, Jemez, and Pecos/Las Vegas, although the project area does not include the Pecos/Las Vegas Ranger District.

The SFNF manages lands for multiple uses, including recreation, grazing, wildlife habitat, fisheries, watersheds, and heritage resource protection and interpretation. Lands surrounding the SFNF are undeveloped areas (open grasslands and low-, mid-, and high-elevation forest ecosystems), dispersed residential developments, small towns, villages, and Pueblos, a national research center (LANL), ski areas, reservoirs, and agricultural areas, including both ranches and small irrigated farms.

Existing ROWs on the SFNF are those for transmission lines, water lines, fiber-optic cables, communication facilities, roads and highways, pipelines, and other infrastructure that support local, regional, and national interests.

3.4.1.2 Recreation

Recreation planning on NFS lands is an integral part of land and resource management planning, as required by the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976, and described in 36 CFR, Part 219, and Forest Service Manual 1920.

Recreation opportunities in the project area range from dispersed uses, such as hiking and wildlife viewing, to developed recreation, such as that for campgrounds and interpretive sites. Recreation is an important component of the multiple use management practices of the SFNF. Surveys cited in the PEIS (2008) demonstrate that recreation on Forest Service lands is increasing annually (BLM and Forest Service 2008). Steady population growth continues to increase the recreation demand on undeveloped public lands as visitors and nearby residents seek a diversity of recreation.

The Recreation Opportunity Spectrum (ROS) is both a classification system and a prescriptive tool for recreation planning, management, and research (Clark and Stankey 1979). The Forest Service uses ROS to illustrate the recreation setting by describing a combination of the physical, biological, social, and managerial conditions that give value to a place.

The ROS embodies six land classes, as follows, along with the number of acres in the project area on lands managed by the SFNF (Forest Service GIS 2015):

- Primitive—0 acres
- Semi-primitive non-motorized—9,415 acres
- Semi-primitive motorized—85,973 acres
- Roaded natural—74,309 acres
- Rural—398 acres
- Urban—0 acres

Each setting provides experiences that range from a sense of isolation and closeness to nature (at the primitive end of the spectrum) to social experiences in highly structured environments (at the urban end of the spectrum).

The SFNF includes a diversity of landscapes, offering visitors a variety of recreation settings and opportunities. Providing these outdoor recreation opportunities is a primary goal identified in the Forest Service's Strategic Plan for Fiscal Years 2015 to 2020 (Forest Service 2015a). In the plan, the Forest Service has identified the following key aspects for managing recreation resources on system lands:

- Maintain recreation settings, hiking trails, and other sustainable recreation opportunities on National Forests and Grasslands for public use
- Improve recreation facility accessibility
- Help meet public needs and expectations for outdoor recreation on National Forests and Grasslands through public and private partnerships
- Improve our communication of outdoor recreation information about the National Forests and Grasslands on the Internet, social media, and other outlets to reach more people, serve them better, and receive their feedback
- Encourage community planning for sustainable tourism and recreation, providing private landowners with economic incentives to maintain open space
- Use tools such as the ROS and the Scenery Management System to help identify, prioritize, protect, and enhance open spaces
- Maintain water of sufficient quantity and quality to sustain aquatic life and support terrestrial habitats, domestic uses, recreation opportunities, and scenic character
- Develop sustainable recreation settings and opportunities along with programs that complement national, state, and community tourism strategies

In addition to planning documents, the aspects of the regulatory framework for recreation are provided in the 2008 Geothermal PEIS (BLM and Forest Service 2008). Since publication of the 2008 PEIS, the SFNF completed updates to its Forest Plan (Forest Service 1987), including identifying management areas for recreation, providing management rules for special designations areas, and restricting motor vehicles to the route network displayed on motor vehicle use maps.

SFNF Recreation Areas

The SFNF previously administered the VCNP, formerly the Baca Ranch, but it is now a preserve under the NPS. Bandelier National Monument, also administered by the NPS, is east of the project area, near LANL, on the Pajarito Plateau.

An estimated 591,000 to 676,000 people visited the Jemez Ranger District in 2012. Holiday weekend visitation can increase dramatically. For example, on Memorial Day weekend in 2003, visitation was 163 percent above the average weekday (MRCOG 2006). Most SFNF recreation users travel NM 4 from the Albuquerque area. Almost all of the Jemez Ranger District developed recreation sites are found along NM 4 and NM 126. The notable exception is Paliza Family and Group campgrounds, which are located off Forest Road 10 (Forest Service 2015b).

Recreation use is generally light to moderate throughout the broader project area, except along major routes, such as NM 4, and around campgrounds, hot springs, rivers, and population centers, such as Jemez Springs, where peak-season visitation during the summer can be high. In April and May there is a dramatic increase in day-use hikers. Trailhead parking is full during weekends and mostly full during the weekdays. Forest roads are opened to the public in mid-April and visitors begin to use the dispersed camping areas. By early May the developed sites are open to the public and are busy throughout the summer. Campgrounds and dispersed camping areas continue to be used during the fall big game hunting seasons. As winter approaches the most developed sites are winterized and closed. Forest roads typically close in early January and are used as cross-country ski and snowmobile trails (Forest Service 2015b).

There are 1,089 miles of motorized routes that crisscross the SFNF project area (Forest Service GIS 2015). The Travel Management Rule (36 CFR, Part 212) establishes requirements for National Forest transportation systems. It also describes the requirements for designating roads, trails, and areas for motor vehicle use on a motor vehicle use map.

In addition, there are a number of designated recreation areas on the SFNF, such as the San Antonio, Jemez Falls, Jemez Canyon, Laughing Water, Redondo, Las Conchas, Horseshoe Springs, and Paliza, which total to over 5,000 acres (Forest Service GIS 2015).

Within the project area, there are six campgrounds (all on the Jemez Ranger District) and four picnic sites (three on the Jemez Ranger District and one on the Coyote Ranger District; Forest Service GIS 2015). Primitive camping is allowed throughout, unless otherwise posted and not within 100 feet of a riparian area.

NMDGF Hunt Units 5B, 6A, 6B, 51A, and 51B are partially or entirely in the project area. Permitted hunting is through the NMDGF, although an additional habitat stamp is required to hunt on federal lands. Typical hunted species are mule deer, elk, turkey, and other small game animals.

3.4.1.3 Special Designations

The following section describes special management designations on the project area, including IRAs, National Recreation Areas (NRAs), National Historic and Scenic Trails, Wilderness Areas, and Wild and Scenic Rivers. These areas have been designated to protect unique characteristics and contain resources that have been identified as scientifically, educationally, or recreationally important. Special area designations on NFS lands can be established by Congress or Presidential Proclamation or administratively by USDA. The Forest Service has the authority to adopt many, but not all, special management designations through Forest Plan amendments or revisions, such as the management designations detailed in the SFNF Plan (Forest Service 1987).

Inventoried Roadless Areas

IRAs are a Forest Service administrative designation representing some of the nation’s most highly valued expanses of open space.

There are seven IRAs in the SFNF project area covering approximately 15,800 acres. IRAs can be characterized by nine values or features, which are described below. The 2001 Roadless Rule

(36 CFR, Subpart 294.43) places restrictions on resource extraction and road construction/reconstruction in IRAs.

The 2001 Roadless Rule lists the following nine values or features that often characterize IRAs:

- High-quality or undisturbed soil, water, and air
- Sources of public drinking water
- Diversity of plant and animal communities
- Habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species that depend on large, undisturbed areas
- Primitive, semi-primitive non-motorized, and semi-primitive motorized recreation opportunities
- Reference landscapes
- Natural-appearing landscapes with high scenic quality
- Traditional cultural properties and sacred sites
- Other locally identified unique characteristics

Seven IRAs are distributed in the northern and southern portions of the project area. Youngsville (6,000 acres), Pueblo Mesa (1,100 acres), Canones Creek (3,900 acres), and Polvadera (1,200 acres) are all in this northern area; Virgin Canyon (600 acres), Peralta Ridge (800 acres), and Alamo Canyon (2,200 acres) are in the far south (Forest Service 2016a).

National Recreation Areas

The Forest Service establishes NRAs primarily to protect important recreation, scenic, scientific, and natural values for the enjoyment of current and future generations. The highlighted activities center on water- and land-based pursuits associated with the natural environment.

The JNRA is in the project area. It was established in 1993 and consists of over 28,000 acres, managed by the Jemez Ranger District, and abuts portions of the VCNP. The SFNF administers the lands to promote the area for fishing, camping, rock climbing, hunting and hiking. Mining in this NRA is prohibited, except on preexisting claims, and the JNRA Act withdrew the area from geothermal development. The JNRA (Public Law 103-104, Stat. 1025) requires the SFNF to protect, conserve, and restore natural resource values in the JNRA.

National Historic, Scenic, and Recreational Trails

The National Trails System is made up of National Scenic Trails, National Historic Trails, and National Recreation Trails. National Scenic Trails and National Historic Trails are congressional designations given to protected areas in the United States that contain trails and surrounding areas of particular natural beauty and historic significance. National Recreational Trails are designated based on applications from diverse partnerships, and include more than 1,200 trails on federal, state, local, and privately owned land throughout the country. National Trails are officially established under the authorities of the National Trails System Act (16 USC, Subsection 1241-51).

National Scenic Trails are 100 miles or longer, continuous, primarily non-motorized routes of outstanding recreation opportunity. National Historic Trails commemorate historic and prehistoric routes of travel that are of significance to the entire nation. National Historic Trails have as their purpose the identification and protection of the historic route and its historic remnants and artifacts for public use and enjoyment (NPS 2006a). They must meet three criteria listed in Section 5(b)(11) of the National Trails System Act:

- They must follow actual documented route of historic use
- They must be of national significance
- They must possess significant potential for public recreation and interpretation

Within the SFNF, there is one federally designated National Scenic Trail: the Continental Divide Trail. It runs along the Continental Divide of North America and crosses the SFNF for a total of 25.7 miles on the Cuba and Coyote Ranger Districts[1], but not within the project area (Forest Service 2016b). There are no National Historic Trails within the project area; however, the Old Spanish National Historic Trail is located north of the project area. The Canones Creek National Recreational Trail is the only National Recreational Trail in the project area, extending 6.2 miles from the Cerro Pavo trailhead through Canones Canyon near Coyote.

National Scenic Byways

The National Scenic Byways Program (NSBP; 23 USC 162) was authorized in 1991 and is administered by the Federal Highway Administration (FHWA). The FHWA designates National Scenic Byways when roads have outstanding scenic, historic, cultural, natural, recreational, and archaeological qualities. NSBP funding supports projects that manage and protect these intrinsic qualities, interpret these qualities for visitors, and improve visitor facilities along byways. The National Scenic Byway in the project area is the Jemez Mountain Trail National Scenic Byway. It is approximately 65 miles long, 21.8 miles of which fall within the project area. It provides scenic opportunities for viewing geological formations, ancient Native American ruins, Jemez Pueblo, and an area rich in historic logging, mining, and ranching (Forest Service GIS 2015). The portion of the Jemez Mountain Trail National Scenic Byway within the project areas is within the JNRA.

Wilderness Areas

The National Wilderness Preservation System was created to ensure the preservation and protection of natural conditions in areas designated as wilderness. On the SFNF, there are of four wilderness areas (Pecos, San Pedro Parks, Chama River Canyon, and Dome), although none are in the project area.

Wild and Scenic Rivers

Congress established the National Wild and Scenic Rivers System to effectively manage special river segments. Rivers, or segments of rivers, must be free flowing and possess at least one outstandingly remarkable value, such as scenic, recreational, geologic, fish, wildlife, historic, cultural, or other features. The outstandingly remarkable values of eligible rivers must be protected until superseded by Congress. Within the National Wild and Scenic Rivers System, three classifications define the general character of designated rivers: wild, scenic, or recreational. Classifications reflect levels of development and natural conditions along a stretch of river. These classifications are used to help develop management goals for the river.

[1] Mathew Chavez and Anne Bishop, Forest Service, personal communication with Holly Prohaska, EMPSi. March 2, 2016.

The SFNF has three Wild and Scenic Rivers: The Rio Chama, Pecos, and the East Fork of the Jemez River. However, only 9 miles of the East Fork of the Jemez River fall within the current project area, all of which is in the JNRA (Forest Service GIS 2015).

3.4.2 Environmental Consequences

3.4.2.1 Scoping Comments on Land Use, Recreation, and Special Designations

The following issues specific to land use, recreation, and special designations were identified during the public scoping period:

- How would geothermal leasing impact IRAs and their sensitive resources?
- How would geothermal leasing impact adjacent wilderness areas, lands with wilderness characteristics, IRAs, and ACECs or other special designations?
- How would geothermal leasing affect recreation in the project area? How would geothermal leasing affect the JNRA and other nearby recreation areas managed by other federal or state agencies?

3.4.2.2 How Resource Impacts Were Evaluated

Methods

Land status baseline information, recreation data, and special designation areas in **Section 3.4** were reviewed for an understanding of SFNF management practices, designations, and land use in the project area. The SFNF GIS data (Forest Service GIS 2015) were overlain with the actions found under each alternative in **Chapter 2**. Conclusions were drawn based on an understanding that these types of actions may affect NFS lands and adjacent landowners.

Indicators

The following indicators have been identified in order to evaluate potential impacts on land use, recreation, and special designation areas:

- Conflict with management goals and objectives set forth by the Forest Service to sustain the health, productivity, and diversity of federal lands
- Result in proposed uses that are incompatible with existing or adjacent land uses
- Result in a change of recreation access
- Conflict with existing recreation uses of the area
- Diminish existing recreation experiences and opportunities by altering the recreation setting
- Conflict with management goals and objectives set forth by the Forest Service in order to categorize, protect, and manage special designation areas
- Conflict with conservation goals for the area
- Result in proposed land uses that are incompatible with adjacent special designation areas

Assumptions

This analysis assumes the following:

- The SFNF’s consent or denial of NFS lands for geothermal leasing and its issuance of geothermal leases would not impact land use and access. Existing ROWs and communication sites would be managed to protect valid existing rights. However, impacts could result from future construction and operation of geothermal energy projects in the project area, based on future leases.

- Congressionally designated wilderness areas would be closed to leasing.
- Current land use could change once site-specific geothermal operations begin. Under travel management, new roads created for a specific project would probably not be open to recreational use.
- Demand for recreation opportunities would increase over time.

3.4.2.3 Common Impacts Associated with Geothermal Development

Due to the inability to predict the location, scope, scale, and timing of future development, the following impact analysis provides a general description of common impacts on land use from geothermal development. The information presented in the Common Impacts on Land Use with Geothermal Development section of the 2008 Geothermal PEIS is incorporated by reference and summarized here (BLM and Forest Service 2008). **Chapter 2** summarizes the alternative-specific data.

Lands converted to geothermal use during the drilling and utilization phases (well pad, power plant, pipeline, and transmission line construction and uses) could result in long-term indirect impacts on other uses, such as grazing, recreation, hunting, and mining, because geothermal use could displace these activities and uses. Short-term (lasting only the duration of the actual activity) impacts could include maneuvering construction and maintenance equipment and vehicles associated with the drilling and utilization activities. Further, reclamation and abandonment would likely return the landscape to its pre-construction condition, and the previous uses and activities could resume.

The development of geothermal resources could also alter the physical, social, and operational character of the recreation setting, thereby changing an individual’s experiences. All phases of development, including surveying, drilling, utilization, operation, and maintenance, could restrict recreation areas, temporarily reducing the amount of land available for recreation and accessible trails. This could displace some recreationists and could limit recreation. Recreationists could experience an increase in noise, vibration, and dust. Additionally, exploration could shift the ROS setting. Under travel management, new roads created for a specific project would probably not be open to recreational use. However, this would also alter the experience for people seeking a more remote experience in those same areas.

Increased traffic from reclamation and abandonment could affect timely public access, as described above. All disturbed lands would be reclaimed in accordance with Forest Service standards, and recreation activities could resume, improving recreation opportunities.

3.4.2.4 Impacts Under Alternative 1—No Action

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. The JNRA would remain closed to geothermal leasing, and no direct impacts would occur in this area. Geothermal lease stipulations and closures would not be specifically implemented on recreation areas or special designations outside of the JNRA; however, any geothermal lease applications and nominations would be subject to the standards and guidelines outlined in the Forest Plan and subsequent environmental analysis.

3.4.2.5 Impacts Under Alternative 2—Proposed Action

Relevant stipulations detailed in **Chapter 2** and designed to protect existing land uses are CSU stipulations in and around popular recreation areas, TLs to benefit wildlife, and NSOs to ensure sensitive and special designation areas are protected. These measures are expected to effectively avoid or minimize direct and indirect impacts identified in **Section 3.4.2.3** on land uses, recreation and special designation areas by identifying conflicts early in the process and requiring specific measures to maintain public uses and values. Implementing lease stipulations under Alternative 2 would minimize impacts.

More trucks, possible road improvements, and more people could diminish the overall recreation experience on the SFNF. Further, traffic noise may disrupt the experience of people staying in campgrounds and picnic areas along NM 4 and NM 126. Evening and night traffic from trucks and project equipment would be light, but traffic noise from evening and night travel could indirectly impact campers' experience. Daytime traffic may have fewer impacts because many campers are elsewhere during the day, in contrast to users of picnic areas that are open only during the daytime.

Special designations in the project area, including the Wild and Scenic segment of the East Fork of the Jemez River, the JNRA, Canones Creek National Recreation Trail, and the seven IRAs, are either closed to leasing or are subject to NSO under Alternative 2. No direct impacts would occur in these areas. The Jemez Mountain Trail National Scenic Byway, 21.8 miles of which fall within the project area, could include minor, temporary impacts from congestion resulting from large, long-wheelbase construction vehicle traffic during geothermal exploration and development phases.

Overall, this alternative would result in greater limitations for the siting of geothermal infrastructure, compared to Alternative 1, which could result in more concentrated areas of development. Recreation experiences and opportunities may be diminished by increased visual and noise impacts. These impacts would occur in areas not subject to leasing closures or NSO stipulations.

Compared with Alternative 1, Alternative 2 provides specific guidance to ensure that a National Forest-wide approach is adopted and that land use issues are considered across all users of the SFNF.

3.4.2.6 Impacts Under Alternative 3—No Leasing

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. Under the no lease alternative, there would be no direct or indirect impacts on land use, recreation, or special designations in the project area.

3.4.2.7 Impacts Under Alternative 4—Development

Relevant stipulations and closures detailed in **Chapter 2** would be designed to protect special designation areas, such as IRAs, the JNRA, Scenic Trails, recreation areas, and land uses. Impacts would be similar to those described under Alternative 2. However, because of the greater access to SFNF lands and fewer overall restrictions, Alternative 4 may have greater indirect impacts—such as noise, fugitive dust, and visual intrusions—on special designation areas, recreation opportunities, and land uses on the SFNF.

The JNRA is closed to leasing under Alternative 4. However, there could be impacts on other types of recreation areas, including remote portions of the SFNF and areas currently valued for solitude and low-density visitation. More trucks, possible road improvements, and more people could reduce the overall recreation experience on the SFNF, compared to Alternative 3. Traffic noise may disrupt the experience of people staying in campgrounds and picnic areas along NM 4 and NM 126. Evening and night traffic from trucks and project equipment would be light, but traffic noise from evening and night travel could indirectly impact campers' experience. Daytime traffic may have fewer impacts because many campers are elsewhere during the day, in contrast to users of picnic areas that are open only during the daytime.

Other special designations in the project area, including the wild and scenic segment of the East Fork of the River, Canones Creek National Recreation Trail, and the seven IRAs are either closed to leasing or subject to NSO under Alternative 4. No direct impacts would occur in these areas. The Jemez Mountain Trail National Scenic Byway, 21.8 miles of which fall within the project area, could include minor, temporary impacts from congestion, resulting from large, long-wheelbase construction vehicle traffic during geothermal exploration and development.

3.4.2.8 Cumulative Impacts, Land Use, Recreation, and Special Designations

Consent to the issuance of a geothermal lease has no direct impact on the environment (40 CFR, Subpart 1508.8[a]); however, it is a commitment of the resource for potential future exploration, drilling operations and development, utilization, and reclamation and abandonment. These would be subject to environmental review under NEPA and project-specific permitting from the BLM and the SFNF. However, any future development of geothermal resources, if and when it does take place, may result in impacts, whether deemed significant or not. It is reasonable, therefore, to foresee that on-the-ground impacts on land use, recreation, and special designation areas may occur if the Forest Service consents to leasing and the BLM issues geothermal leases. Those impacts would not occur, however, until some point in the future, following several decision stages.

Past and present activities that have had cumulative impacts on land uses, recreation, and special designation areas are wildfire, mining, ranching, timber cutting, road building, off-road vehicle riding, and dispersed camping, including in sensitive riparian areas, such as along the wild and scenic portion of the East Fork of the Jemez River near Las Conchas.

Reasonably foreseeable future actions are the proposed South Pit Pumice Mine Expansion, the Duran 2010 Pumice Mine, and the VCNP designation as a significant geothermal feature under the Geothermal Steam Act of 1970 (30 USC, Section 1019). The two pumice mines are on the Jemez Ranger District and could have a cumulative impact on recreation and land uses. Specifically they could have indirect impacts related to noise, traffic, fugitive dust, and visual intrusions. Further, if the NPS successfully nominates the VCNP as a significant thermal feature under the Geothermal Steam Act, areas next to the caldera, or those with hydrological connections, may not be leased; this could reduce potential indirect impacts on land uses, recreation, and special designations. Other reasonably foreseeable actions could include potential fire management activities, timber sales, mineral leases, and transmission lines

Incremental cumulative impacts are not anticipated under Alternative 3, because the project area would be closed to geothermal leasing. Under Alternatives 2 and 4, there would be incremental cumulative impacts on recreation, including noise, fugitive dust, increased traffic, and visual intrusions that may diminish recreation experiences. However, special designation areas would not be affected, due to NSO stipulations. Further, any ground disturbance or other future actions that would occur under Alternatives 2 and 4, would require further decision-making under NEPA. This would involve a wide variety of factors; examples are policy initiatives about timing of actions, whether any applications are submitted or any funding is available, and compliance with other authorities and policies. The use of TLs, CSUs, and NSOs should minimize conflicts with land use, recreation, and special designation areas, as should individual analyses under NEPA that would determine project-specific direct, indirect, and cumulative impacts. Alternative 1 would also follow this action-specific NEPA process.

3.5 Geologic Resources

3.5.1 Affected Environment

3.5.1.1 Geologic Setting

The project area is in the Jemez Mountain region of northern New Mexico, to the west of the Rio Grande Valley. It sits at the southern margin of the Rocky Mountain ecoregion on the west side of the Rio Grande Rift Zone. The Jemez Mountains are part of the Jemez Lineament, which is a chain of volcanic centers extending from Arizona to Colorado. The Rio Grande Rift is a feature where the crustal plate is separating that stretches from the Colorado Rockies to Mexico. The project area lies above the intersection of the Jemez Lineament and the Rio Grande Rift. A dormant super-volcano beneath the project area has erupted numerous times due to tectonic movements (Muldavin and Tonne 2003). The last eruption occurred 40,000 to 50,000 years ago. The Valles Caldera crater was created by a massive eruption 1.25 million years ago and is now a 13-mile-wide crater-shaped landscape and contains the 89,000-acre ranch that is now the VCNP. This is bordered on three sides by the project area (Forest Service 2016c).

The Jemez Mountains and Valles Caldera are composed of Quaternary Period alluvial and landslide deposits, welded Bandelier tuff, Tertiary basalt, basaltic-andesite, or rhyolite and breccias. These are clastic sedimentary rocks, which originated from volcanic activity in the region 13 million years ago. These rocks overlie Tertiary, Mesozoic, and Paleozoic sedimentary rocks, which in turn overlie Precambrian granitic basement rock. More specifically, the Paleozoic Madera limestone underlies the redstones, siltstones, and shale of the Abo Formation, with the Mesozoic Chinle formation and the Tertiary Santa Fe Group and Abiquiu tuff superseding. The more permeable layers of volcanic tuff allow for groundwater to occur in perched aquifers above the relatively impermeable Abo Formation (Forest Service 2016c).

The rocks are down-faulted to the east into the Rio Grande Rift. Unconsolidated Tertiary sediments of the Santa Fe Formation thicken eastward toward the axis of the rift. The Jemez Mountains volcanics occur at the intersection of the rift with the northeast-trending Jemez Lineament, a line of Miocene to Quaternary volcanic fields extending across the northwest portion of New Mexico (Aldrich and Laughlin 1984; Shevenell et al. 1987).

The Chama River cuts through the southeastern Colorado Plateau and southern Rocky Mountains, which consists of high mesas dissected by tributaries of the Rio Chama and its main stem. Rock units exposed in the lower reach of the river are the Ojo Caliente sandstone, Abiquiu tuff, and Lobato basalt (Wells 2009).

Downstream of the Abiquiu Reservoir, to the confluence of the Rio Chama with the Rio Grande, and following the Rio Grande downstream to its confluence with the Jemez River, the valley floors also consist of Tertiary Period partly compacted sands and gravels of the Santa Fe group or Quaternary Period alluvium. The Santa Fe Group consists of alluvial fans, river channel deposits, and interbedded volcanic rocks. Several of the mesas are capped by Triassic Period basaltic to andesitic lava flows (NRCS 2011a).

3.5.1.2 Geologic Hazards

Seismic Activity

The project area lies above several faults. There were 54 earthquakes in the vicinity of the SFNF between 1962 and 2014, with the largest having a magnitude 3.5. The probability of an earthquake exceeding magnitude 5.0 in the project area in the next 20 years ranges from 3 percent to 15 percent (USGS 1999). A magnitude 5.0 earthquake may damage poorly constructed structures but have little to no damage on well-constructed structures. Small earthquakes are expected to continue to occur in the vicinity of the project area (Forest Service 2015c).

Seismic activity can be caused by human activity in areas with certain types of faults and a critical state of stress in the rocks. Changes in pore pressure, or stress, on a fault may occur when fluids are injected into or extracted from a well. This change may lead to movement along that fault, resulting in a seismic event. Increased seismicity in the central United States in recent years has been linked to injection of wastewater or other fluids in high volumes over an extended period in deep disposal wells (Petersen et al. 2015). Geothermal development has been associated with induced seismicity but only in cases of Enhanced Geothermal Systems (i.e., injecting and withdrawing fluids from rock formations to enhance rock permeability and recover heat from the rock; Majer et al. 2012). The seismic events believed to have resulted from this activity have almost all been of relatively small magnitude. Most of these events are rarely felt by the time the seismic energy reaches the surface (Majer et al. 2007).

The USGS is working to create a seismic hazard model that incorporates induced seismicity into predictions of probability of future seismic events. A 2014 report prepared by the USGS states that forecasting the seismic hazard from induced seismicity is fundamentally different from forecasting the seismic hazard for natural seismic activity. This is due to the economic and policy factors that affect where fluid extraction and injection occurs. The report concludes that the rates of induced earthquakes are inherently variable and non-stationary and therefore are extremely difficult to predict on a multi-year basis (Petersen et al. 2015). As a result, the risk of induced seismicity in the project area cannot be accurately predicted at this time.

The USGS has identified 17 areas in the central and eastern United States that contained seismicity suspected to have been induced by fluid injection or removal. These areas are called induced seismicity zones. New Mexico contains two such zones—the Raton Basin near the New Mexico-Colorado border and Dagger Draw in southeastern New Mexico. While earthquakes recorded in these zones could be natural, the USGS believes they may be induced seismicity. This is because the earthquakes are all located near deep fluid injection wells or other industrial activities capable of inducing earthquakes (Petersen et al. 2015). Neither of the induced seismicity zones in New Mexico are in or near the project area.

Volcanic Activity

There is a long history of volcanic activity in northern New Mexico, including the SFNF (Schwab et al. 2008). All of the volcanoes on or near the SFNF are considered extinct, except for those in the Valles Caldera. As discussed in Geologic Setting, above, the project area surrounds three sides of the Valles Caldera and sits above a dormant super-volcano. The volcano has not erupted in the past 40,000 to 50,000 years. However, new magma has been seen in the volcanic deposits beneath the project area, suggesting that “the Jemez Mountains volcanics field may be entering a new phase of activity” (Dunbar 2010). Those studying the area conclude that the volcanic features beneath the project area are likely to erupt again but that the next eruption may not occur for thousands, or even tens of thousands, of years (Dunbar 2010). Studies of magma bodies in New Mexico indicate that magma deposits may occur as little as 2.5 miles below the earth’s surface; however, most of the deposits are believed to occur between 3.7 and 11.8 miles below the surface (Sanford 1983; Fialko and Simons 2001).

Naturally Occurring Radioactive Material

Some geologic formations, including the Mancos Formation in northwestern New Mexico, contain low levels of radioactive materials, such as uranium and thorium, and their decay elements, radium 226 and radium 228 (USGS 1999). These elements emit the same levels of radiation that humans are generally exposed to on a daily basis (BLM 2014). These naturally occurring radioactive materials (NORM) can be brought to the surface during drilling operations that remove fluids from the radioactive formation (Sumi 2008).

Pipes and other equipment that handle large volumes of water flowing out of formations over the long term can become coated with scale deposits that contain radium (USGS 1999). Radiation levels on these pipes may increase above background levels over time to a level that can be dangerous to those who handle the equipment (USGS 1999). However, the radiation is weak enough that it cannot penetrate dense materials, such as the steel used in pipes and tanks, to contaminate the surrounding environment (BLM 2014).

3.5.2 Environmental Consequences

3.5.2.1 Scoping Comments on Resource

The following issues specific to geologic resources were identified during the public scoping period:

- What are the impacts on geologic resources from geothermal developments? Could there be increased risk for induced seismicity or other geologic hazards as a result of geothermal leasing? If so, what are the indirect impacts of geologic hazards, considering the proximity of the Abiquiu Dam and LANL?
- Is baseline seismic monitoring or additional fault mapping required to determine the risk of induced seismicity or other geologic hazards associated with geothermal exploration or development?

3.5.2.2 How Resource Impacts Were Evaluated

Method

The potential impacts of geothermal development were evaluated by assessing the impacts that anticipated future actions under the alternatives would have on the geologic resources of the project area.

Indicators

The following indicators have been identified in order to evaluate potential impacts on geology and seismicity:

- Changes in seismic activity, including both natural and induced seismicity
- Changes in volcanic activity
- Release of NORM into the environment
- Ground subsidence

Assumption

This analysis assumes that further environmental analysis would be completed before enhanced geothermal systems are authorized in the project area.

3.5.2.3 Common Impacts Associated with Geothermal Development

The information presented in the Common Impacts on Geology Resources and Seismic Setting Associated with Geothermal Development section of the 2008 Geothermal PEIS is incorporated by reference and summarized here.

Although the concerns identified above in the *Indicators* are discussed here and in the 2008 Geothermal PEIS, due to the inability to predict future types of development, the timing, and locations, the potential for these impacts to occur can only be fully evaluated once a site-specific proposal is submitted. Any subsequent, site-specific projects that might occur in the project area would undergo NEPA review, during which geotechnical investigations may be conducted, if deemed necessary.

Seismic risk could increase if geothermal resource development includes high pressure reinjection along any faults intersected by the injection well. However, the risk is reduced where geothermal fluid withdrawn from the resources is used and then re-injected into the system for a near zero net change.

While the project area has had historic volcanic activity and has the potential for future volcanic activity, geothermal development in the project area is not expected to affect the risk of this activity. As discussed under *Affected Environment*, studies of magma bodies in New Mexico indicate that magma deposits may occur between 2.5 and 11.8 miles below the earth's surface, though most deposits occur at least 3.7 miles below the surface (Sanford 1983; Fialko and Simons 2001). The deepest geothermal wells are drilled to approximately 2.2 miles below the surface, and most are shallower than that (Finger and Blankenship 2010; Brown 2009 [Fenton Hill]). Therefore, the potential for a geothermal well to encounter a magma deposit is low.

NORM can be released from subsurface formations during withdrawal of groundwater associated with geothermal development. However, as discussed under *Affected Environment*, the radioactivity cannot penetrate the materials used in geothermal development equipment. Therefore, the potential for release of these materials into the environment is low.

Subsidence can occur where groundwater is pumped from underground aquifers at a rate exceeding the rate at which it is replenished. Most geothermal development techniques include re-injecting the geothermal fluid after the heat is used and maintaining static pressure of the geothermal reservoir. Therefore, the potential for subsidence is low.

Enhanced Geothermal Systems

The process of stimulating production and injection wells by injecting water under pressure, and often at a much cooler temperature than the receiving rock, results in the expansion of existing fractures and sometimes the creation of new fractures through the movements of masses of rock at depth. This fracturing method is commonly referred to as hydro-shearing or shearing. These movements result in seismic activity. Since the seismic activity is created by the reservoir stimulation, it is distinguished from natural seismicity by the term *induced seismicity*. Whether or not the induced seismicity can be felt at the surface depends on the depth of the reservoir, the degree to which the rock masses are shifted from the stimulation, and the nature of the overlying geology and its ability to transfer the shock waves to the surface.

Typically, natural fractures vary in length on a scale of 1 to 10 meters. Seismic energy radiated during the shearing process depends on the length of the fracture or the stress release from the constraining natural forces. Most of the observed data from existing Enhanced Geothermal Systems projects suggest that the higher energy radiated from the shearing is caused by a high stress release from relatively small joint lengths (Michelet et al. 2004). This would suggest that if there were some perceived seismicity on the surface, the frequency content would be too high to generate any seismic risk, but minor events may still raise concern among local inhabitants. As part of the NEPA process for any specific Enhanced Geothermal Systems proposal, mitigation measures, such as seismic monitoring requirements, would be developed to address the potential for seismic-related risks.

Protocols

The International Energy Agency developed a peer-reviewed and accepted protocol for addressing induced seismicity during geothermal projects, and the DOE has adopted it (Majer et al. 2012). Such protocols may be made a requirement of any enhanced geothermal systems project. The protocol calls for the following steps to be taken for a site-specific project:

- Perform a preliminary screening evaluation
- Implement an outreach and communication program
- Review and select criteria for ground vibration and noise
- Establish seismic monitoring
- Quantify the hazard from natural and induced seismic events
- Characterize the risk of induced seismic events
- Develop risk-based mitigation plan

Induced Seismicity Hazards Risk Analysis

If desired by the operator or required by the Forest Service, an independent consultant can be contracted to prepare an induced seismicity and seismic risk hazards analysis. Such analyses identify and quantify the risk associated with induced seismicity and can focus its content on potential impacts on nearest communities and homeowners.

Prediction of Event Number and Magnitude

Recent advances have been made in predicting the number and magnitude of induced seismicity that can be expected during hydro-shearing operations. If desired by the operator or required by the Forest Service, mechanisms of induced seismicity can be quantified and a “seismogenic index” can be developed for a specific area. Such an index would characterize the potential number of induced seismicity events greater than a particular magnitude as a function of the injected volume. Changes to injection rates and total fluid volumes can be used during operations to manage seismic impacts. The maximum allowable magnitude is determined by the induced seismicity and seismic hazard risk analysis. Evaluation of the seismogenic index will allow project geologists to place initial bounds on the hydro-shearing operational and mitigation limits for a given project.

Control of Rate and Bleeding Pressure after Injection

Mitigation measures can be implemented if induced seismic events approach defined limits. The primary mitigation method may be reducing the rate of water injection to a level where an induced seismicity rate and magnitude are within an acceptable range. A secondary method can be to backflow the well to reduce reservoir pressure.

The utilization phase of Enhanced Geothermal Systems projects could produce micro-seismic events. Seismic data collection arrays may be set up before any well stimulation so that induced seismicity can be monitored in real time. This monitoring allows supervising geologists to track where the reservoir is opening up and allows operations to be modified, as needed. The ongoing monitoring of micro-seismicity with multi-station sensor arrays would allow regulators to continuously review the project and halt or modify operations if the risk to properties is considered to be too great.

3.5.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations.

Projected geothermal development under Alternative 1 may increase the impacts on geologic resources, described under *Common Impacts Associated with Geothermal Development*. As noted under *Common Impacts Associated with Geothermal Development*, these impacts of increased seismic risk, volcanic activity, release of NORM, and subsidence are all low. While the risk of increased seismicity cannot be quantified at this stage, development using enhanced geothermal systems would not be authorized without further analysis of the risks of induced seismicity associated with a proposed project.

3.5.2.5 Impacts Under Alternative 2

Impacts under Alternative 2 on geologic resources would be the similar as those described under Alternative 1. BMPs identified in Appendix C include monitoring during all phases of development and adaptive management strategies developed at the project level. These measures would reduce the risk of geologic hazard impacts.

3.5.2.6 Impacts Under Alternative 3

Under Alternative 3, the entire project area would be closed to geothermal leasing. Therefore, the impacts described under *Common Impacts Associated with Geothermal Development* would not occur.

3.5.2.7 Impacts Under Alternative 4

Impacts under Alternative 4 on geologic resources would be the same as those described under Alternative 2.

3.5.2.8 Cumulative Impacts

Cumulative impacts on geologic resources from geothermal exploration, drilling, and development are expected to be minor. BMPs identified in Appendix C—such as geotechnical investigations and monitoring, and mitigation of impacts from future drilling activities—would be implemented. Any impacts from development that might occur would be minimal and largely limited to the project site. Seismic events related to geothermal reservoir injection could cumulatively contribute to seismic events triggered by multiple operations; however, the risk of seismic events triggered by specific geothermal development activities cannot be assessed at this time.

3.6 Energy and Mineral Resources

3.6.1 Affected Environment

In this section, energy and mineral resources are discussed, along with their association with geothermal resources. This section addresses the Forest Service's general regulatory framework for energy and mineral resource development, regulations particular to the project area, energy resources and activity in New Mexico and the project area, and mineral resources and activity in New Mexico and the project area.

Wind, solar, biomass, and geothermal energy are considered renewable energy resources. The Forest Service manages these activities under 36 CFR, Part 251, Subpart B. These resources all have different factors influencing the feasibility of their development. However, some issues are common to all, including distance to existing power transmission facilities and compatibility with existing federal land use.

On federal lands, mineral resources are governed by the General Mining Law of 1872, as amended; those portions of the FLPMA that affect the General Mining Law; the Mineral Leasing Act of 1920; the Surface Resources Act of 1955; and the Mining and Minerals Policy Act of 1970. Oil and gas leasing is guided by the Energy Policy Act of 2005, and geothermal leasing is guided by the Geothermal Steam Act of 1970 (30 USC 1004), as amended by the Energy Policy Act of 2005.

The Forest Service manages oil and gas operations on NFS lands under 36 CFR, Part 228, Subpart E. Mineral leasing operations are guided by Forest Service Manual 2820; mineral prospecting, including geophysical activities, is guided by Forest Service Manual 2860. Locatable minerals and surface management regulations fall under 36 CFR, Part 228, Subpart A, and Forest Service Manual 2810. Mineral materials are regulated under 36 CFR, Part 228, Subpart C, and Forest Service Manual 2850. Within the SFNF, the right to occupy and use surface lands as reasonably necessary to carry on prospecting mining is guided by 16 USC, Subsection 482(j).

A portion of the project area overlaps the JNRA. Subject to valid existing rights, lands in the recreation area are withdrawn from locatable mineral entry under the General Mining Law of 1872 and the Mineral Leasing Act of 1920, 16 USC, Subsection 460jjj-2(b). Locatable mineral development is similarly prohibited with 0.25 mile of the high water mark on either side of the East Fork of the Wild and Scenic Jemez River. As a result, nearly one-quarter of the project area is withdrawn from locatable mineral entry.

3.6.1.1 Energy Resources in New Mexico

New Mexico is an energy exporter, producing 2.4 times as much energy as it consumes (New Mexico Energy, Minerals & Natural Resources Annual Report 2015). In 2014, New Mexico exported 13 million megawatt hours of electricity (EIA 2014). Coal, crude oil, natural gas, uranium, hydroelectric, solar, wind, and geothermal resources are all being developed in the state.

The state ranks sixth nationally in crude oil production, seventh in dry natural gas production, twelfth in coal production, 38th in electricity production. It is home to over a quarter of proven US coal-bed methane reserves, second only to Colorado. These resources are produced largely on federal lands, but approximately 25 percent is produced on state lands, with fractional amounts produced on private and tribal lands (EIA 2015b).

Electric utilities must meet the State's renewable portfolio standard by including a State policy-determined proportion of renewable energies in their total generating capacity. Investor-owned utilities must have no less than 20 percent of their generation come from renewable energies by 2020, while rural electrical cooperatives, like the Central New Mexico Electric Cooperative, must have no less than 10 percent by 2020. In 2007, the New Mexico Public Regulation Commission issued an order requiring renewable generation used to meet the standard to include no less than 30 percent wind, 20 percent solar, 5 percent other renewable technologies, and 1.5 percent distributed generation (New Mexico Public Regulation Commission 2016).

Historically, coal and natural gas have been the major fuel sources for electrical generation in New Mexico. Since 1990, these fuels have accounted for over 90 percent of the state's generation. Wind and solar accounted for 7 percent of that capacity, while hydro-electric and petroleum combined contributed less than 0.5 percent. In 2013, geothermal energy sources generated 0.0002 percent (or 69 megawatt hours) in the state (EIA 2016).

From 1870 to 1890, the US Army Corps of Engineers surveyed much of New Mexico and identified the following as geothermal waters: the San Ysidro Spring, Ojo Caliente, Ponce de Leon Warm Springs, San Antonio Hot Springs, San Antonio Warm Springs, Jemez Hot Springs, Montezuma Hot Springs, Apache Tejo Warm Springs, Faywood Hot Springs, and the Mimbres Hot Springs (Summers 1976).

In the mid-1960s, the State of New Mexico took on its own effort to inventory geothermal waters in the state. It identified sources in Gila River Basin, Rio Grande Basin, Pecos River Basin, Tularosa Basin, and San Juan River Basin, to varying extents (Summers 1976).

In the early 1980s, the New Mexico Energy and Minerals Department funded two projects to use geothermal energy, both outside of the project area. The first, at Carrie Tingley Hospital, used geothermal waters to heat a pool used for physical therapy treatments. The second used geothermal water as a low-temperature space heating system at a senior citizens center (Lund and Witcher 2002).

3.6.1.2 Energy Resources in the Santa Fe National Forest Project Area

The project area is in the Albuquerque-Santa Fe Rift province identified in the USGS National Oil and Gas Assessment (Molenaar 1995). There has been no oil or gas production in the project area, and none is expected during the next 20 years. There are no active or pending coal leases in the project area, and coal resources have not been identified there (Hoffman 1996).

As discussed in **Chapter 1**, *Purpose of and Need for Action*, the project area contains the lands identified by SFNF as most likely to receive geothermal lease nominations and applications, based on the favorability of its geothermal resources (see **Figure 1-3**, Geothermal Potential Areas). However, no geothermal development has occurred in the project area to date, largely due to the lack of transmission lines there.

The RFDS prepared by SFNF (BLM 2015) projects development of 15 temperature gradient wells and 5 slim wells over the expected life of the plan. Development of five 25-MW binary power plants containing six wells each is also predicted. See BLM (2015) for detailed explanation of the different types of geothermal wells.

There are no active or pending proposals for wind energy in the project area, and there is little potential for wind energy development. There is no known potential for hydroelectric power in the project area.

3.6.1.3 Mineral Resources in New Mexico

The earliest mining in the region started around 1870 with the production of sheet mica (Bingler 1968). This mineral is now used primarily in the electronic industry due to its unique electrical, insulating, and mechanical properties (Dolley 2008). As demand for sheet mica declined, a market for electrical mica grew through World War II. Since then, most of the mica mined in New Mexico has been processed for scrap mica (Dolley 2008). In the early twentieth century, mineral production was primarily for sand and gravel. However, some commercial development occurred for gold, silver, copper, lead, zinc, molybdenum, fluorite, and crushed and ornamental stones (Bingler 1968).

3.6.1.4 Mineral Resources in the SFNF Project Area

For many centuries, local populations in the SFNF used clay for ceramics and stones for buildings. Turquoise was commercially developed and transported from the area. High-grade copper deposits were also mined by the Spanish and Indians (Gillio 1979; Bingler 1968). Some lead was also mined for bullets.

There are no active mineral operations in the project area. The SFNF is offering portions of the project area for pumice mining through a competitive sale. Pumice deposits are common in and around the project area, due to ancient volcanic eruptions (Schwab et al. 2008).

While other minerals exist in the project area, known occurrences are too small and low grade to be economically mined and transported to processing plants. Therefore, development of other minerals in the project area is not expected during the life of the Forest Plan.

3.6.2 Environmental Consequences

3.6.2.1 Scoping Comments on Resource

There were no issues specific to energy and mineral resources identified during the public scoping period.

3.6.2.2 How Resource Impacts Were Evaluated

Method

Impacts of energy and minerals were evaluated by examining whether leasing areas for geothermal resources would have the potential to impact mining, oil and gas leasing, and electricity generation or transmission or the subsequent development of those resources.

Indicators

The potential impacts of geothermal development were evaluated by assessing the impacts that anticipated future actions consistent with implementation of the alternatives described in **Chapter 2** would have on energy and mineral resources. Geothermal leasing would have no direct impacts on energy and mineral resources. Impacts would occur from subsequent development. Potential impacts on energy and mineral resources could occur if reasonably foreseeable future actions were to have any of the following impacts:

- Result in the construction of transmission lines that would affect the feasibility of other energy development along the transmission corridor
- Develop roads that would encourage other energy and mineral exploration in otherwise undeveloped areas
- Occupy portions of the project area in a manner that precludes extraction of other minerals or development of energy infrastructure

Assumptions

This analysis assumes the following:

- If the prescription for an administrative designation, as described in the applicable land use plans, allows for geothermal leasing, then these areas could remain open to geothermal leasing, at the discretion of the Forest Supervisor.

3.6.2.3 Common Impacts Associated with Geothermal Development

Improving existing roads and constructing new roads for geothermal resource exploration, production, operation and reclamation and abandonment of geothermal resources would have a negligible to minor impact on the exploration for other energy and mineral resources in the immediate area. The degree of impact would depend on the existing limits to access in the area and the distance of the roads to the other mineral resources. Introducing new transmission lines would encourage developing other energy resources along the transmission line. Mineral resource developments would be encouraged due to the new availability of power for their operations. These impacts would be reduced with increased distance from mineral resources to the power plant, roads, and transmission lines.

Drilling operations would hinder the development of other energy or mineral resources on the same land; however, after reclamation and abandonment of geothermal operations, developers of other energy sources could use the property. Any other ongoing operations in the area that use these facilities would have to take over maintenance of shared facilities, such as roads and transmission lines, or they would also be reclaimed.

The extent of all of these impacts in the project area would be limited due to the low amount of current and expected energy and mineral development in the project area. While additional roads and transmission lines would encourage additional energy and mineral development, other limitations associated with those resources in the project area may still prevent their development.

3.6.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations.

The Forest Plan calls for sound energy and minerals exploration and development administered “to minimize adverse surface resource impacts.” It directs Forest supervisors to respond to geothermal lease applications in a timely manner; however, the availability of roads and utility corridors is subject to certain restrictions. For example, reconstruction and rehabilitation of existing roads is emphasized over new road construction. Roads constructed for mineral activities would be built and maintained by the permittee to minimum standards for the intended use. Similarly, utility corridors are prohibited in some management areas while placement in others would require extensive mitigation measures.

Under Alternative 1, the RFDS prepared by the SFNF (BLM 2015) predicts that fifteen temperature gradient wells, five slim wells, and five 25-MW binary power plants (with six wells each) would be developed in the project area over the life of the plan. Developing these facilities could increase accessibility to otherwise undeveloped areas and result in the construction of transmission lines. However, there would be a negligible impact on other non-geothermal mineral and energy resources, due to the low amount of projected development.

3.6.2.5 Impacts Under Alternative 2

Under Alternative 2, the SFNF would manage approximately 17 percent of the project area as closed to geothermal leasing. Another 79 percent would be open, subject to NSOs, 48 percent would be open subject to CSUs, and 23 percent would be open subject to TLs.[2] Approximately 1 percent of the project area would be open to geothermal leasing, subject to standard stipulations.

In accordance with the RFDS (BLM 2015), the amount of expected geothermal development would be the same as Alternative 1. Therefore, the impacts of that development on other energy and minerals resources would be the same as those described under Alternative 1.

3.6.2.6 Impacts Under Alternative 3

Under Alternative 3, the entire project area would be closed to geothermal leasing. Therefore, the impacts described under *Common Impacts Associated with Geothermal Development* would not occur. There would continue to be a reliance on other forms of energy production and electrical generation in the region, the majority of which come from fossil fuels.

3.6.2.7 Impacts Under Alternative 4

Under Alternative 4, the SFNF would manage approximately 17 percent of the project area as closed to geothermal leasing. Another 73 percent would be open subject to NSOs, 73 percent would be open subject to CSUs, and 25 percent would be open subject to TLs. Approximately 2 percent of the project area would be open to geothermal leasing, subject to standard stipulations.

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[2] The percentages add up to greater than 100 percent because some stipulations overlap.

In accordance with the RFDS (BLM 2015), the amount of expected geothermal development would be the same as Alternative 1. Therefore, the impacts of that development on other energy and minerals resources would be the same as those described under Alternative 1.

3.6.2.8 Cumulative Impacts

Geothermal development in the project area could change the electricity generation mix in New Mexico by increasing the proportion of geothermal energy used to provide electricity and decreasing the proportion associated with other energy sources. This would occur only where geothermal resources are developed to produce electricity, and not where they are developed for direct use. Under Alternatives 1, 2, and 4, the development of five 25-MW geothermal power plants in the project area would add up to 1.1 million megawatt hours per year of geothermal-produced electricity to New Mexico’s energy mix. The additional geothermal electricity generated would make up less than 1 percent of the total electricity produced in New Mexico; however, it would contribute to the state’s renewable energy standard mandate, calling for 5 percent of an investor-owned utility’s electrical generation to come from renewable energies other than wind, solar, and distributed generation (EIA 2015b [Supply and Disposition of Electricity]; NMAC 17.9.572).

Alternatively, Alternative 3, at a minimum, would maintain reliance on other forms of energy production and electrical generation – the majority of which are generated by burning fossil fuels like coal and natural gas.

3.7 Paleontological Resources

3.7.1 Affected Environment

Paleontological resources, or fossils, are the remains, imprints, or traces of once living organisms preserved in rocks, sediments, and caves. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. The fossil record is the only evidence that life on earth has existed for more than 3.6 billion years. Fossils are considered nonrenewable resources because the organisms they represent no longer exist (BLM and Forest Service 2008).

Fossils are managed for scientific, educational, and recreational values, such as collecting invertebrate fossils and petrified wood for a hobby, and to protect these resources from any impacts. Primary regulations governing the protection and conservation of paleontological resources on federally administered lands includes the Antiquities Act of 1906 and the Paleontological Resource Preservation Act (Sections 6301-6312 of the Omnibus Public Lands Act of 2009, 16 USC, Section 470[aaa]). The Antiquities Act protects both historic and prehistoric resources on federal lands, and the Paleontological Resource Preservation Act provides specific protections for paleontological resources, mandating the management and preservation of those resources on public lands, using scientific principles and expertise. In addition, FLPMA (Public Law 94-579) requires that public lands be managed in a manner that protects the “quality of scientific” and other values, and NEPA requires protections for “important historic, cultural and natural aspects of our national heritage.”

The SFNF issued nine reconnaissance/collecting permits for paleontological resources between 1997 and 2014. Seasonal interns researched, documented, and published paleontological work on northern New Mexico NFS lands in 2004. They identified 1,335 fossil localities in Rio Arriba, Sandoval, Santa Fe, Los Alamos, San Miguel, and Mora Counties. Of these sites, 240 are within the SFNF boundary or within a 2-mile buffer around the SFNF. The site data were used to determine the formations' potential for vertebrate fossil occurrence (Forest Service 2015c).

As required by Forest Service Manual 2882.6, the SFNF classified its NFS lands for fossil potential using the Paleontological Resources Rapid Assessment System (PRRAS), the results of the 2004 project, and more recent work. SFNF is using this information and PRRAS rankings to manage activities on NFS lands with the potential to disturb or degrade the scientific value of the paleontological resources. The PRRAS classification has the following categories: fossil occurrence likely (2), fossil occurrence likelihood unknown (1), and fossil occurrence unlikely (0). The project area includes geologic units classified as PRRAS 2, 1, and 0, as shown below (**Table 3-2**).

Table 3-2. PRRAS Classification for Project Area

PRRAS Classification	Geologic Units	Acreage
Fossil occurrence likely (2)	Abo Formation, alluvium, Chinle Group, Cutler Formation, Dakota sandstone, Lower and Middle Santa Fe Group, Madera Formation, Mancos shale, Morrison Formation, piedmont alluvial deposits, San Andres limestone, Glorieta sandstone, Santa Fe Group, Paleogene sedimentary units, and Yesa Formation	68,800
Fossil occurrence likelihood unknown (1)	Landslide deposits and colluvium, basaltic volcanics, and Bandelier tuff	69,300
Fossil occurrence unlikely (0)	Neogene basalt and andesite flows, Neogene volcanic rocks, silicic volcanic rocks, silicic to intermediate volcanic rocks, and Valles rhyolite	56,700

Sources: Forest Service 2015c; Forest Service GIS 2015

The project area includes 68,830 acres with geologic units classified as PRRAS 2 (likely fossil occurrence) (Forest Service 2015c). These geologic units mostly range in age from the Jurassic Era to the Early Pleistocene. Of particular importance are the deposits of Early Paleocene mammals that are extremely well preserved in these units. These deposits represent an excellent record of the rapid mammalian diversification, following the extinction of the dinosaurs at the end of the Cretaceous (BLM and Forest Service 2008). By the late Eocene, all the modern orders of mammals had evolved and were represented by species that were ancestral to the modern forms known today. As climates cooled, the tropical and subtropical forests of the Paleocene and early Eocene gave way to more open woodlands; continued global cooling and drying led to the evolution of grassland ecosystems during the Miocene. General adaptive strategies for mammalian groups at this time included an increase in body size, the ability to digest grasses, and a trend toward a greater emphasis on running.

Decades of scientific investigation have recovered various fossil remains from these geologic units, including early reptiles, eohippus (the first horse), camelids, rhinoceroses, gomphotheres (ancestors of modern elephants), oreodonts, dogbears, large cats that could be considered saber-toothed, and many other extinct orders, families, and genera (Kues and Lucas 1979; SFNF 2015).

3.7.2 Environmental Consequences

3.7.2.1 Scoping Comments on Resource

There were no issues specific to paleontological resources identified during the public scoping period.

3.7.2.2 How Resource Impacts Were Evaluated

Method

The PRRAS classification, described above in **Table 3-2**, describes the potential for paleontological resources within a given geological unit and the potential sensitivity that should be considered in project planning; however, it does not mean that paleontological resources are actually present within those specific units.

The analysis area for paleontological resources is the project area. The potential impacts of geothermal development were evaluated by assessing the impacts that anticipated future actions under the alternatives would have on the paleontological resources.

Indicators

Potential impacts on paleontological resources could occur if anticipated actions consistent with implementing the alternatives described in **Chapter 2** were to involve the following:

- Surface disturbance, such as building roads or preparing drill sites or plant sites, that could directly impact paleontological resources
- Surface disturbance that could expose geologic units with potentially important paleontological resources, leading to impacts from vandalism or unsupervised and unpermitted fossil collection
- Surface disturbance that could cause indirect impacts from increased erosion of important fossil resources

General indicators were evaluated, along with those considered in the Geothermal PEIS (BLM and Forest Service 2008).

Assumptions

This analysis assumes that leasing land for potential geothermal development does not involve ground-disturbing activities or any type of construction, so there would be no direct impact on paleontological resources. Any impacts would result from activities pursued after leasing.

3.7.2.3 Common Impacts Associated with Geothermal Development

The Geothermal PEIS (BLM and Forest Service 2008) provides a general description of common impacts on paleontological resources from geothermal resource development, although it is not possible to predict specific future development scenarios, including types of development, timing, and location.

Impacts on nonrenewable surface or subsurface paleontological resources, particularly those involving PRRAS 2 classifications (fossil occurrence likely), could result from destruction by breakage and crushing during surface-disturbing actions. Surface disturbance related to geothermal development has the potential to impact an unknown quantity of fossils that may occur on or underneath the surface in areas containing paleontologically sensitive geologic units classified as PRRAS 2 (fossil occurrence likely).

Without mitigation, these fossils, as well as the paleontological data they could provide if properly salvaged and documented, could be destroyed, rendering them permanently unavailable. Impacts can typically be mitigated to below a level of significance by implementing CSU or NSO stipulations, such as avoiding or minimizing work in areas with PRRAS 2 classifications (fossil occurrence likely). Mitigation also results in the salvage of fossils that may never have been unearthed as the result of natural processes. With mitigation, these newly exposed fossils become available for scientific research, education, display, and preservation into perpetuity at a public museum.

Impacts also result from the continuing implementation of management decisions and associated activities. For paleontological resources, impacts most commonly occur as the result of management actions that increase the accessibility of public lands, increasing the potential for loss of paleontological resources by vandalism or unsupervised and unpermitted collecting (poaching). These impacts are difficult to mitigate to below the level of significance, but they can be greatly reduced by increasing public awareness about the scientific importance of paleontological resources through education, community partnerships, and interpretive displays and by informing the public about penalties for unlawfully destroying or collecting these resources.

3.7.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan (Forest Service 1987) and existing laws and regulations. There would be no impacts on paleontological resources in the JNRA.

Geothermal lease stipulations and closures would not be specifically implemented on paleontological resources outside of the JNRA; however, any geothermal lease applications and nominations would be subject to the standards and guidelines outlined in the Forest Plan and subsequent environmental analysis. The types of impacts that could occur would be the same as those described under *Common Impacts Associated with Geothermal Development*.

3.7.2.5 Impacts Under Alternative 2

Impacts under Alternative 2 on paleontological resources would be similar to those described under Alternative 1. However, additional lands would be identified as closed to leasing or subject to NSO, CSU, and TL stipulations. Closures and stipulations would not be specifically implemented for paleontological resources; however, closures and stipulations for other resources would also protect geologic units with likely fossil occurrences. In PRRAS 2, 8,400 acres would be closed to geothermal leasing, 39,400 acres would be subject to NSO stipulations, and 25,700 acres would be subject to CSU stipulations (Forest Service GIS 2015).

In accordance with BMPs identified in Appendix C, if paleontological resources are present at a site, or areas with a high potential to contain paleontological material have been identified, a paleontological resource management plan would be developed. The potential is low for geothermal development to impact sensitive geologic units (those classified PRRAS 2 [fossil occurrence likely]), considering geothermal leasing closures, stipulations, and BMPs.

3.7.2.6 Impacts Under Alternative 3

Under Alternative 3, the entire project area would be closed to geothermal leasing. Therefore, the impacts on paleontological resources described under *Common Impacts Associated with Geothermal Development* would not occur.

3.7.2.7 Impacts Under Alternative 4

Impacts under Alternative 4 on paleontological resources would be similar to those described under Alternative 2; however, fewer acres of PRRAS would be subject to NSO stipulations and closures, and more acres would be subject to CSU stipulations. In PRRAS 2, 7,800 acres would be closed to geothermal leasing, 35,900 acres would be subject to NSO stipulations, and 35,800 acres would be subject to CSU stipulations. The potential is low for geothermal development to impact sensitive geologic units (those classified PRRAS 2 [fossil occurrence likely]), considering geothermal leasing closures, stipulations, and BMPs.

3.7.2.8 Cumulative Impacts

Consenting to issue a geothermal lease has no direct impact on the environment (40 CFR, Subpart 1508.8[a]); however, it is a commitment of the resource for potential future exploration, drilling operations and development, utilization, and reclamation and abandonment. These would be subject to environmental review under NEPA and project-specific permitting from the BLM and the SFNF. However, any potential future development of geothermal resources may result in impacts, whether deemed significant or not. It is reasonable, therefore, to foresee that cumulative impacts on sensitive geologic units (those classified PRRAS 2 [fossil occurrence likely]) could occur if the Forest Service were to consent to leasing and the BLM were to issue geothermal leases under Alternatives 1, 2, and 4. Those impacts would not occur, however, until some point in the future, following further decision-making under NEPA. Moreover, the use of CSU or NSO stipulations would likely minimize or avoid impacts on paleontological resources.

Alternative 3 would have no cumulative impacts on paleontological resources.

3.8 Soil Resources

3.8.1 Affected Environment

The soils of the project area are primarily characterized by those typical of the region. The primary soil classifications in the project area are inceptisols, alfisols, entisols, and mossisols. Specific soil types and distributions by unit can be found in the Soils and Water Specialist Report (Forest Service 2016c).

3.8.1.1 Soil Erosion

The soil erosion hazard is a measure of the susceptibility of the soil to erode when its surface is exposed to water. A rating of severe indicates that predicted potential soil loss rates have a high probability of reducing site productivity due to erosion. **Table 3-3**, below, summarizes the area of severe erosion hazard by unit. The project area includes 107,775 acres of severe erosion hazard, making up 55 percent of the entire project area. Over 82 percent of the area in the Lease Interest Unit and Middle Unit is rated as severe. Locations of areas with severe soil erosion hazard are depicted in the Soils and Water Specialist Report (Forest Service 2016c).

Table 3-3. Soil Characteristics of the Project Area

	Unit					
	JNRA Unit	Lease Interest Unit	Middle Unit	North Unit	South Unit	Totals
Area of Severe Erosion Hazard per Unit in Project Area						
Area of severe erosion hazard in unit (acres)	18,880	32,561	11,528	29,460	15,346	107,775
Percent of unit with severe erosion hazard	48	83	82	43	45	55
Percent of Each Wind Erodibility Group per Unit in the Project Area						
WEG 1	0	0	0	0	1	0
WEG 2	0	0	0	23	0	8
WEG 3	0	0	0	14	0	5
WEG 4L	12	29	33	5	12	14
WEG 5	21	12	61	10	6	16
WEG 7	35	59	0	42	65	45
WEG 8	33	0	6	7	15	12
Percent of Each Hydrologic Soil Group per Unit in the Project Area						
A: Low runoff potential/high infiltration rate	0	0	0	0	0	0
B: Moderately low runoff potential	68	21	67	56	45	50
C: Moderately high runoff potential	0	41	0	19	0	15
D: High runoff potential/very slow infiltration rate	32	38	33	25	55	35

Sources: Forest Service 2016c

3.8.1.2 Wind Erodibility

The wind erodibility group (WEG) is a Natural Resources Conservation Service (NRCS) designation for a grouping of soils that have similar properties affecting their susceptibility to wind erosion. The ranking ranges from 1 to 8, with 1 being the most susceptible to wind erosion. Data group 1 is fine sand, sand, and coarse sand. A data group of WEG 8 would indicate soils that are not susceptible to wind erosion due to rock and pararock[3] fragments at the surface. **Table 3-3**, Soil Characteristics of the Project Area, summarizes the percent of land in each WEG by project area unit.

The soils of the project area are not particularly susceptible to wind erosion, with the exception being some of the soils in the North Unit. Across the project area, 73 percent is covered by soils that are categorized as WEG 5 or higher, with large tracts of land (57 percent of the project area) categorized as WEG 7 or 8. Locations of WEG designations are depicted in the Soils and Water Specialist Report (Forest Service 2016c).

[3] Soft rock fragments

3.8.1.3 Soil Runoff Potential

A hydrologic soil group is soils that have similar runoff potential under similar storm and cover conditions. The classification reflects the soil's runoff potential from rainfall. The rankings range from A to D, with A being the lowest runoff potential and highest infiltration rates and D having the highest runoff potential and lowest infiltration rates. **Table 3-3**, Soil Characteristics of the Project Area, summarizes the percent of area covered by each hydrologic soil group by project unit.

The soils in the project area tend to have a moderate to high runoff potential. Seventy-nine percent of the Lease Interest Unit area has either a moderately high or high runoff potential. The locations of hydrologic soil group designation in the project area are depicted in the Soils and Water Specialist Report (Forest Service 2016c).

3.8.1.4 Shrink/Swell Potential

Shrink/swell potential is the relative change in volume to be expected with changes in moisture content. The change in volume can exert enough force on a building or structures to cause structural damage to buildings, other structures, and roads. Most of the project area has a low shrink/swell potential, but the Lease Interest Unit has a few larger areas of moderate shrink/swell potential. Shrink/swell potential is further described in the Soils and Water Specialist Report (Forest Service 2016c).

3.8.2 Environmental Consequences

3.8.2.1 Scoping Comments on Resource

There were no issues specific to soil resources identified during the public scoping period.

3.8.2.2 How Resource Impacts Were Evaluated

Method

Available soils data for the project area was analyzed to determine the susceptibility of the soils to erosion and potential transport by surface flow. The analysis also examines areas of expansive soils where construction may be difficult.

The soil erosion hazard data are from the Terrestrial Ecological Unit Inventory, which classifies ecological types and maps terrestrial ecological units to a consistent standard throughout NFS lands (Forest Service 2005).

The WEG is soils that have similar properties affecting their resistance to soil blowing. These data were adopted from the NRCS.

The Digital General Soil Map of the United States, or STATSGO2, is a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape and that can be mapped at the scale of 1:250,000 in the continental United States. The United States General Soil Map is composed of general soil association units and is maintained and distributed as a spatial and tabular dataset from the NRCS. This level of soils data was used for the existing condition of soils in the project area.

Indicators

The consent or denial of NFS lands for geothermal leasing and the issuance of geothermal leases would not directly impact soils. However, indirect impacts would result from future construction and operation of geothermal energy projects in the project area, based on future leases. Indicators of impacts of the proposed action and alternatives are as follows:

- Susceptibility of soils in the project area to water erosion, as measured by the soil erosion hazard
- Susceptibility of soils in the project area to wind erosion, as measured by the WEG
- Potential for runoff and sediment transport in the project area, as measured by the hydrologic soil condition
- Area of expansive soils (shrink/swell potential)

Assumptions

- The potential impacts of the alternatives were evaluated on the basis of extent of area that would be open for exploration and development and the general presence of easily eroded soils.

3.8.2.3 Common Impacts Associated with Geothermal Development

A detailed description of geothermal development operations relative to soil resources is in the 2008 Geothermal PEIS (BLM and Forest Service 2008) and is summarized in this section. Common impacts on soil resources from geothermal development are physical disturbance (such as movement or removal), compaction, and changes to erosion patterns.

Impacts on soils could include direct disturbance due to development of roads and facilities associated with exploration and development of geothermal production sites. Development could lead to erosion and sedimentation of soils. There would be some loss of soil productivity. Exposed soil surfaces would be vulnerable to the impacts of wind and surface water runoff during construction and operations.

Surface water erosion could remove some soils from the disturbed sites, potentially carrying them into streams and other water resources. In addition, some areas may be subject to deposition of wind-blown material outside the footprint of construction areas or the loss of soil due to wind erosion.

Soils would be directly impacted by grading activities during construction. The degree of risk of erosion and transport due to water and wind depends on the eventual location of disturbances, such as roads and facilities.

There would be a long-term commitment of soil resources in areas that are converted to non-soil surfaces (such as geothermal structures and ancillary facilities) and therefore removed from productive use. This loss may be temporary, as in disturbance surrounding sites or along edges of roads, or long term, due to construction of impermeable surfaces, such as drilling pads and power plants. The loss is not permanent, because all surfaces would be reclaimed if exploration is unsuccessful or after production ceases.

3.8.2.4 Impacts Under Alternative 1—No Action

Alternative 1 would have the same general impacts on soil resources associated with the RFDS as described under *Common Impacts Associated with Geothermal Development*, above. Although the SFNF would not make an availability determination for geothermal leasing in the project area, geothermal lease applications and nominations would continue to be processed on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan (Forest Service 1987) and existing laws and regulations.

Geothermal leasing stipulations and closures would not be specifically implemented related to soil resources; however, any future geothermal lease applications and nominations would be subject to standards and guidelines outlined in the Forest Plan and environmental analysis.

3.8.2.5 Impacts Under Alternative 2—Proposed Action

Under Alternative 2, impacts from anticipated geothermal exploration and development would generally be the same as those described under Alternative 1; however, the location of potential sites would be restricted by administrative withdrawals and stipulations. Approximately 32,000 acres, or 17 percent of the NFS lands in the project area, would be closed to geothermal leasing; approximately 136,650 acres would be allocated as open to geothermal leasing, subject to existing laws, regulations, formal orders, and stipulations.

Implementing NSO stipulations on soils with severe erosion hazard would limit the amount of potential erosion from soil disturbance. Preventing facility development on slopes in excess of 40 percent would further limit both erosion and sediment transport potential. This would minimize the potential impacts, particularly in areas that do not have a severe erosion hazard (and therefore are subject to NSO) but do have a high runoff potential. However, roads and powerlines could still likely cross areas of severe erosion hazard and potentially areas of steep slopes; therefore, there would still be a risk of erosion and transport due to road construction, reconstruction, use, eventual reclamation, and powerline construction. In all units, BMPs identified in Appendix C could be implemented to minimize any potential impacts.

3.8.2.6 Impacts Under Alternative 3

There would be no direct impacts on soils under Alternative 3. No surface areas would be disturbed by geothermal developments. However, there would be indirect impacts on soil resources. Because the area would be closed to leasing for the foreseeable future, over time, there would be less soil disturbance than expected under the implementation of the current Forest Plan.

3.8.2.7 Impacts Under Alternative 4

Impacts on soils would be similar to those described under Alternative 2. However, allowing surface occupancy on areas of severe erosion hazard by implementing only CSU stipulations on these soils would increase the risk of erosion and sediment transport in areas disturbed for exploration and development of geothermal sites under Alternative 4. This would be a particular concern on steeper slopes of between 30 and 40 percent and areas with moderately high to high runoff potential. Implementing BMPs identified in Appendix C to minimize and contain any erosion could reduce the impacts on soil productivity.

3.8.2.8 Cumulative Impacts

Cumulative impacts for soil resources are analyzed at the sixth-level watersheds that overlap or encompass the project area. Past, present, and reasonably foreseeable future actions are discussed in **Section 3.3.4**.

Water resource repair and replacement projects—the Pueblo of Jemez Red Rocks Dam Repair, the Abiquiu Land Grant Waterline Replacement, and the McKinney County Dam—will initially directly impact soil resources through digging and removing soil resources. These surface-disturbing activities could cause additional erosion and sedimentation into waterways. Mineral development projects—the South Pit Pumice Mine Expansion and the Duran 2010 Pumice Mine—would involve significant soil disturbance for expansion and operation. These activities could increase erosion and reduce soil productivity.

Restoration projects, such as the Southwest Jemez Mountains Restoration Project, Pueblo of Jemez Owl Springs Bridge Sediment Removal Project, and Valle Seco Wetland Restoration Project, would maintain or improve soil conditions in their respective project areas by removing sedimentation and reducing erosion.

Sedimentation and erosion would likely occur from geothermal development, combined with natural processes, such as fires in project area watersheds. The intensity of the combined impacts of fires and geothermal development will depend on the size and severity of the fire, as well as local soil conditions.

There would be the fewest cumulative impacts under Alternative 3, due to the restriction of leasing in the entire project area. Cumulative impacts over the remaining alternatives would be similar, due to the RFDS; however, Alternatives 1 and 4 would likely have the greatest intensity, due to a lack of or reduction of restrictive stipulations on geothermal development.

3.9 Water Resources

3.9.1 Affected Environment

3.9.1.1 Watersheds and Surface Water

The project area lies in the Rio Grande River Basin. The Rio Grande flows from its headwaters in southern Colorado through New Mexico to the border with Mexico, where it turns eastward and marks the border between Mexico and Texas before emptying into the Gulf of Mexico.

Tectonic rifting has defined the route of the Rio Grande through New Mexico over millions of years and has resulted in intense volcanism in the basin. Valles Caldera, surrounded by the project area boundary on three sides, is one of the world’s largest and youngest calderas. Magma underlying the caldera is the source of the geothermal heat in the region.

The project area includes parts of three fourth-level watersheds[4] of the Rio Grande system: Jemez River, Rio Chama, and Rio-Grande-Santa Fe. The three four-level watersheds are further defined as sixth-level watersheds. Parts of 22 nested sixth-level sub-watersheds are included in the project area. **Figure 3-1** shows a map of the sixth-level watersheds within the project area (Watershed Boundary Dataset GIS 2016).

[4] The United States is divided and subdivided into successively smaller hydrologic units. The fourth-level of classification is the cataloging unit. It is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or district hydrologic features. The fourth-level watersheds are further divided into fifth and sixth levels, where the sixth-level watershed is the smallest subdivision, normally encompassing between 10,000 and 40,000 acres. Each hydrologic unit is assigned a name corresponding to its principal hydrologic feature or to a cultural or political feature in the unit.

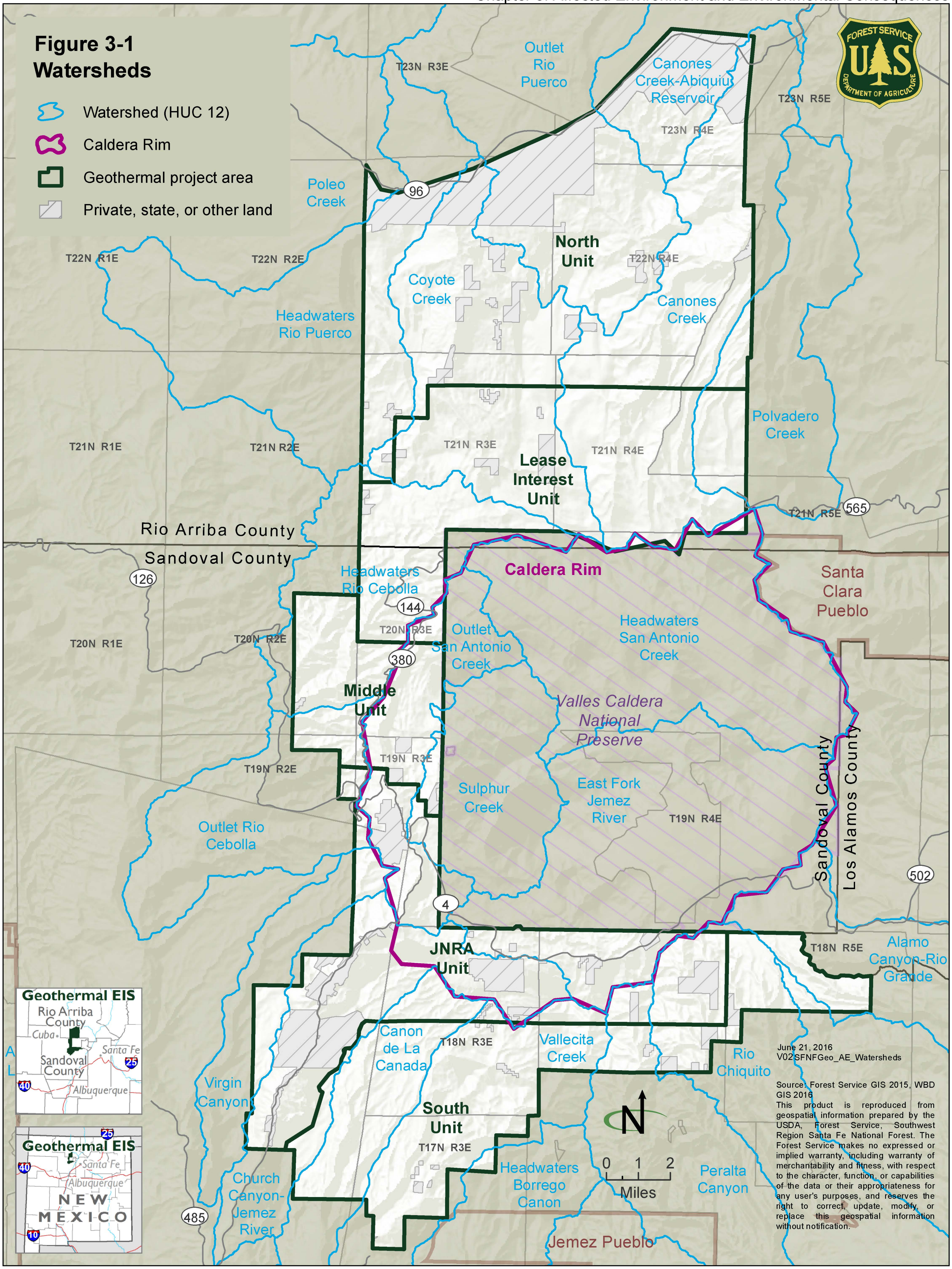
Figure 3-1
Watersheds
Watershed (HUC 12)
Caldera Rim
Geothermal project area
Private, state, or other land
Outlet Rio Puerco
Canones Creek-Abiquiu Reservoir
Poleo Creek
North Unit
Coyote Creek
Headwaters Rio Puerco
Canones Creek
Polvadero Creek
Lease Interest Unit
Rio Arriba County
Sandoval County
Caldera Rim
Headwaters Rio Cebolla
Santa Clara Pueblo
Outlet San Antonio Creek
Headwaters San Antonio Creek
Middle Unit
Valles Caldera National Preserve
Sulphur Creek
East Fork Jemez River
Outlet Rio Cebolla
Sandoval County
Los Alamos County
JNRA Unit
Alamo Canyon-Rio Grande
Canon de La Canada
Vallecita Creek
Rio Chiquito
Virgin Canyon
South Unit
Headwaters Borrego Canon
Peralta Canyon
Church Canyon-Jemez River
Jemez Pueblo
T23N R3E
T23N R4E
T23N R5E
T22N R1E
T22N R2E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
96
126
144
380
4
565
502
485
Geothermal EIS
Rio Arriba County
Cuba
Sandoval County
Santa Fe
Albuquerque
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
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0 1 2
Miles
June 21, 2016
V02 SFNFGeo_AE_Watersheds
Source: Forest Service GIS 2015, WBD GIS 2016
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Some of the sixth-level watersheds overlap the project area to a very minimal extent. However, should activities in these overlapped areas be proposed, the activities could affect watershed conditions, both in the project area and in the larger watershed that extends outside of the project area. Therefore, the watershed analysis takes into account all sixth-level watersheds that overlap part of the project area. Fourth and sixth-level watersheds and their relation to the project area are shown in the Soils and Water Specialist Report (Forest Service 2016c).

Surface water flows in the Rio Grande Basin originate primarily in the high mountain elevations as snow melt during the spring and as monsoonal rainfall during the late summer. Typically, the river reaches its highest discharge between April and June, with its peak levels in May. Natural flows also show variation from year to year due to drought and climate variability (New Mexico Office of the State Engineer 2006). The northern extent of the leasing area, north of the VCNP is part of the Upper Rio Grande Basin and includes the Rio Chama watershed. The Jemez Watershed is in the southern part of the leasing area and includes the Jemez River, the only perennial tributary to the Middle Rio Grande Basin.

The annual flow of the Rio Grande is quite variable. One-third of the approximately 1.1 million acre-feet (long-term average) of native Rio Grande surface water that leaves the Upper Rio Grande comes from Colorado, one-third comes from the Sangre de Cristo Mountains, and another third comes from the Rio Chama watershed. Water storage on the Upper Rio Grande includes waters stored in reservoirs on the Rio Chama, including storage of San Juan Chama Project water. The reservoirs are Heron, El Vado, and Abiquiu (New Mexico Office of the State Engineer 2006). The Abiquiu Reservoir is just north of the project area. (Flow is measured at the Otowi stream flow gage.)

The project area is in the Jemez Mountains, where warm springs originating from subsurface geothermal activity have long been used for bathing and therapy. The Jemez Mountains are relatively wet in comparison to the dryer and lower surrounding country. Part of this precipitation, in the form of rain or snow melt, runs off or is lost to evapotranspiration, but the rest infiltrates and is stored as groundwater. The water supports a dense forest in the high country. The Valles Caldera, surrounded by the project area on three sides, is a defining terrain unit. The Jemez River drains the caldera on the west and then flows south through the project area. The Rio Chama drains the caldera on the north.

Jemez River Watershed

The Jemez Watershed is a fourth-level watershed that covers 44 percent of the project area, primarily in the southwest and south-central portions, and along the east edge of the VCNP. All of the Middle Unit, the southernmost spur of the Leasing Unit, and approximately the western two-thirds of the JNRA Unit and the South Unit are in this watershed. The surface waters draining the Valles Caldera are collected by this watershed’s streams, including the Jemez River and San Antonio Creek.

There are six hot springs located in this watershed. There are also two drinking water sources, one in the JNRA Unit and the other in the southern end of the South Unit.

Ongoing processes and existing conditions in the Jemez Watershed include high sediment erosion and water runoff as the result of forest fires. In addition, the lowering of valleys by river incision is a continuing process. Many valleys are flanked by terraces. Rivers respond by aggrading during climates that promote large sediment yield and large, stable discharges, and incising during climates that produce flash flows and reduce the sediment supply (NRCS 2011c).

There are 10 sixth-level watersheds in the Jemez fourth-level watershed that are partially within the project area, as follows:

- Cañon de la Canada
- Church Canyon-Jemez River
- East Fork Jemez River
- Headwaters Rio Cebolla
- Headwaters San Antonio Creek
- Outlet Rio Cebolla
- Outlet San Antonio Creek
- Sulphur Creek
- Vallecita Creek
- Virgin Canyon

Rio Chama Watershed

The Rio Chama Watershed is a fourth-level watershed that covers approximately 49 percent of the project area, including all of the North Unit and most of the northern portion of the Proposed Leasing Unit. Waters draining the north-facing sides of the Valles Caldera and the northern Nacimiento Mountains, as well as adjacent mountains and valleys, are channeled to the Rio Chama and the Abiquiu Reservoir. Eventually these waters lead to the Rio Grande, north of the project area. There are three drinking water wells along the northern edge of the project area in this watershed. There are no natural thermal features in the portion of this watershed that covers the project area.

The western boundary of the larger Rio Chama Watershed is formed by the Continental Divide and the northeastern edge of the Jemez Mountains. In the east, the watershed is hemmed in by the Tusas Mountains and Black Mesa. The Rio Chama headwaters drain the southern San Juan Mountains, and the river ends at its confluence with the Rio Grande, near Espanola, New Mexico. The upland areas of the drainage basin are significant contributors to Rio Chama flows, resulting in snowmelt-dominated hydrology.

Mean annual precipitation in the basin ranges from 9 to 53 inches, with values dependent on elevation (NRCS 2011a). Ongoing processes and existing conditions in the Rio Chama Watershed include high sedimentation rates caused by landslides in the Mancos shale and high sediment erosion and water runoff as the result of forest fires. In addition, the lowering of valleys by river incision is a continuing process.

There are seven sixth-level watersheds of the larger Rio Chama Watershed that occupy portions of the project area, as follows:

- Cañones Creek
- Cañones Creek-Abiquiu Reservoir
- Coyote Creek
- Headwaters Rio Puerco
- Outlet Rio Puerco
- Poleo Creek
- Polvadero Creek

Many of these sub-watersheds have impairments, due to bank instability and lack of a healthy riparian zone. These impairments have resulted in excess sediment and higher stream temperatures (Levine et al. 2015).

The greatest land use in the Rio Chama Watershed by area is rangeland. Impairments are typical of streams impacted by improper grazing management, which can cause a loss of riparian vegetation, increase habitat and seed source for invasive species that compete with native species, and degrade banks, leading to erosion and sedimentation.

Rio Grande-Santa Fe Watershed

The Rio Grande-Santa Fe Watershed is a fourth-level watershed that covers just 7 percent of the project area. It is in the southeastern extent, on the eastern side of the JNRA Unit, and the eastern side and southern edge of the South Unit. Waters drain into this watershed from the southeast-facing slopes of the Valles Caldera, joining several streams and canyons leading to the Cochiti Reservoir and eventually the Rio Grande. This watershed contains the headwaters of Capulin Creek, which is one of only two perennial steams in Bandelier National Monument. There are no drinking water wells or natural geothermal features in the portion of this watershed that is in the project area.

Outside of the project area, portions of the Rio Grande-Santa Fe Watershed extend into Bernalillo, Los Alamos, San Miguel, Sandoval, and Santa Fe Counties. Elevations range from 5,000 to 13,153 feet and precipitation ranges from 9 to 43 inches annually, depending on elevation.

The hydrologic unit begins at Otowi, west of Pojoaque, New Mexico, in the Upper Rio Grande Valley. Farther downstream, the river enters Cochiti Lake, which marks the northern boundary of the Middle Rio Grande Valley. The hydrologic unit continues downstream to the confluence with the Jemez River.

Ongoing processes and existing conditions in the Rio-Grande Santa Fe Watershed are high sediment erosion and water runoff as the result of forest fires. In addition, the lowering of valleys by river incision is a continuing process. This can be exacerbated by mining sand and gravel from the river channels.

There are five sixth-level watersheds in the Rio Grande-Santa Fe watershed in the project area, as follows:

- Alamo Canyon-Rio Grande
- Capulin Canyon-Rio Grande
- Headwaters Borrego Canyon
- Peralta Canyon
- Rio Chiquito

100-Year Floodplains

One hundred-year floodplains in the project area are delineated in accordance with the Federal Emergency Management Act and are shown in the Soils and Water Specialist Report (Forest Service 2016c). Most of the delineated areas are in the JNRA Unit, along the Jemez River, including the Cañon de San Diego, and extending slightly into San Antonio and Sulphur Creeks. There is also a small section of the East Fork of the Jemez River that crosses into the JNRA Unit that is delineated as a 100-year floodplain. There is also a 100-year floodplain in the portion of the Middle Unit that is crossed by the Rio Cebolla. The delineation of this floodplain extends into the southwestern corner of the Lease Interest Unit. There are also several small sections of tributaries to the Rio Puerco, along the northern edge of the North Unit, that include 100-year floodplains.

Beneficial Uses

The basic authority for water quality management in New Mexico is provided through the State Water Quality Act. It establishes the New Mexico Water Quality Control Commission (NMWQCC), which is the state water pollution control agency for purposes of the federal Clean Water Act. New Mexico's water quality standards define water quality goals by designating uses for rivers, streams, lakes, and other surface waters. The waters are classified by the uses for which they are presently suitable or intended to become suitable. The standards set criteria to protect these uses and establish anti-degradation provisions to preserve water quality. The standards are adopted by the NMWQCC, then approved by the EPA under the federal Clean Water Act.

The New Mexico Environment Department (NMED) is responsible for implementing the federal Clean Water Act in New Mexico and ensuring that surface waters meet their designated beneficial uses and New Mexico state water quality standards. The beneficial uses of the sixth-level project area watersheds are presented in the Soils and Water Specialist Report (Forest Service 2016c). All of the watersheds have the beneficial use of livestock watering/wildlife habitat.

Clean Water Act, Section 303(d), Impaired Surface Waters and Total Maximum Daily Loads

Under the Clean Water Act, Section 303(d), states, territories, and federally recognized tribes that have obtained treatment in a similar manner as states are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by the states, territories, or tribes. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop a Total Maximum Daily Load (TMDL) for these waters (see the Soils and Water Specialist Report [Forest Service 2016c]). TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. The NMWQCC is the issuing agency of water quality standards for interstate and intrastate waters in New Mexico.

In the Jemez Watershed there is one body of water, the 23.81-acre Fenton Lake, with a maximum volume estimated at 264 acre-feet, that is listed as impaired as of the 2010 to 2012 listing cycle. Fifteen reaches of the Jemez Watershed are in the sixth-level watersheds that overlap the project area and are listed as Section 303(d) impaired surface water. Natural conditions contribute to high aluminum concentrations throughout the Jemez Watershed, and impacts on aquatic life are unclear. Many sixth-level watersheds in the Jemez Watershed have aluminum listings, but no TMDLs have been identified yet.

In the Rio Chama Watershed there are seven reaches in the sixth-level watersheds that overlap the project area and are listed as Section 303(d) impaired surface waters.

The Rio Grande-Santa Fe Watershed contains one reach in the sixth-level watersheds that overlap the project area and is listed as a Section 303(d) impaired surface water.

The Soils and Water Specialist Report identifies specific reaches that have been listed as Section 303(d) impaired surface waters.

Watershed Condition Class

The watershed condition framework is a comprehensive approach for restoring priority watersheds on national forests and grasslands (Forest Service 2011). It also provides a consistent way to evaluate watershed conditions at both the national and forest levels. Further explanation of this metric can be found in the Soils and Water Specialist Report (Forest Service 2016c).

The Forest Service completed an assessment of all sixth-level Watersheds on National Forests in 2011. It rated the condition of each watershed as properly functioning, functioning at risk, or functionally impaired. The watersheds were also given ratings for twelve condition indicators.

None of the sixth-level watersheds in the analysis are considered to be properly functioning. Two of the watersheds, Headwaters Rio Cebolla and Outlet San Antonio Creek, are functionally impaired. Both are sub-watersheds of the fourth-level Jemez Watershed and together cover most of the Middle Unit.

Throughout all of the sixth-level watersheds, the categories that are consistently of concern are riparian and wetland vegetation, roads and trails, soil condition, and fire impacts. None of the watersheds scored “good” in these categories. For both roads and trails and soil condition, only two watersheds scored “fair”: Cañones Creek-Abiquiu Reservoir for soil condition and Outlet Rio Puerco for road and trails. All the other watersheds were classified as “poor” for these categories.

These categories are indicators of the following concerns:

- Riparian and wetland vegetation—Vegetation condition
- Roads and trails—Open road density, road maintenance, proximity to wear, and mass wasting
- Soil Conditions—Soil productivity, soil erosion, and soil contamination
- Fire impacts—Fire condition class or wildfire impacts

Watershed Erodibility Index and Road Density

The watershed erodibility index is an indicator of the vulnerability of a watershed to erosion and sedimentation from disturbances determined by evaluating the risk of both erosion and transport to streams. This index weights the area in each watershed covered by each erodibility-transport risk (slight, moderate, severe, or very severe). This provides an overall watershed index number that allows watersheds to be compared to each other and illustrates relative risk across the watershed. The index ranges from 1 to 4, with 1 indicating the entire watershed has only a slight erodibility-transport risk, and 4 indicating that the entire watershed would have a very severe erodibility-transport risk. More information on the method for creating this index number can be found in the Soil and Water Specialist Report (Forest Service 2016c). The watershed erodibility index rating across all of the sixth-level watersheds that overlap portions of the project area ranges from 1.2 to 1.9, with an average of 1.5 (see **Table 3-4**, below).

Problems with road density and poor maintenance can also manifest in soil erosion by resulting in deficiency of drainage, modification of water runoff, and excessive loading of slopes resulting in mass movement such as landslides. Additionally, roads can convert subsurface runoff to

Table 3-4. Watershed Erodibility Index

Watershed Name	Percent of Watershed in Project Area	Road Density (Miles of Road per Square Mile)	Watershed Erodibility Index Rating
Fourth-Level Watershed: Jemez			
Cañon de la Cañada	72.1	5.6	1.2
Church Canyon-Jemez River	77.6	6.1	1.3
East Fork Jemez River	15.1	3.9	1.6
Headwaters Rio Cebolla	70.1	10.5	1.3
Headwaters San Antonio Creek	1.6	5.5	1.5
Outlet Rio Cebolla	16.3	6.5	1.3
Outlet San Antonio Creek	69.5	7.1	1.6
Sulphur Creek	11.0	3.0	1.9
Vallecita Creek	50.0	6.1	1.3
Virgin Creek	22.1	5.0	1.3
Fourth-Level Watershed: Rio Chama			
Cañones Creek	82.0	12.3	1.5
Cañones Creek-Abiquiu Reservoir	21.1	2.5	1.2
Coyote Creek	99.6	6.8	1.6
Headwaters Rio Puerco	21.1	5.7	1.8
Outlet Rio Puerco	47.5	3.3	1.4
Poleo Creek	1.3	7.9	1.7
Polvadero Creek	21.2	5.1	1.7
Fourth-Level Watershed: Rio Grande-Santa Fe			
Alamo Canyon-Rio Grande	6.0	2.9	1.5
Capulin Canyon-Rio Grande	2.1	2.0	1.3
Headwaters Borrego Canyon	0.9	3.1	1.2
Peralta Canyon	9.1	1.4	1.5
Rio Chiquito	28.8	5.3	1.5

Source: Forest Service 2016c

surface runoff and then route the surface runoff to stream channels, increasing peak flows (Megan and Kidd 1972; Ice 1985; Swanson et al. 1987). Roads can also divert stream channels to adjacent channels through surface runoff, increasing discharge and peak flow to the receiving channel and decreasing discharge and peak flows to the diverted channel. Therefore, watersheds with higher road densities have a higher risk of sedimentation of stream channels when there are disturbances in the watershed. The average road density for all sixth-level watersheds that overlap the project area is 5.3 miles of road per square mile.

3.9.1.2 Groundwater

The Rio Grande Aquifer System

The groundwater in the project area is in the Rio Grande aquifer system, which is the principal aquifer in a 70,000-square-mile area of southern Colorado, central New Mexico, and western Texas. The Rio Grande Aquifer is an unconsolidated sand and gravel system, consisting of a network of hydraulically interconnected aquifers in basin-fill deposits along the Rio Grande Valley and nearby valleys. Although some volcanic rocks (like those that make up the majority of the bedrock in the project area), solution-altered carbonate rocks, or extensively fractured beds can yield water in specific areas, the bedrock underlying the Rio Grande Valley and aquifer is relatively impermeable. However, the bedrock in the surrounding mountains is somewhat permeable and acts to collect precipitation for recharge.

Recharge to the Rio Grande aquifer system primarily comes from precipitation in the mountainous areas that surround the basins. Runoff from snowmelt or rainfall spreads across permeable alluvial fans and percolates downward into the aquifer. If the volume of runoff is large or becomes part of a perennial stream, groundwater recharge can be distributed over a much longer reach of stream channel.

Runoff produces most mountain-front recharge to the aquifer system and water from the bedrock aquifers is discharged into the basin fill where the mountains front the Rio Grande Valley (Goff 2002). In some mountainous areas, such as the project area, thick and extensive layers of volcanic rocks are sufficiently permeable to enable large volumes of water to flow through the rocks and directly recharge the basin-fill aquifers. Precipitation falling in the valleys does not contribute to aquifer recharge, because most of it is lost to evaporation and transpiration.

Project Area Hydrogeology

The project area lies in the Jemez Mountains in north-central New Mexico. The most dominant feature of the Jemez Mountains is the large central caldera, or area of collapse, known as the Valles Caldera. It contains a geothermal system that is a classic, liquid-dominated reservoir, overlain by a low-pressure vapor cap and recharged by local water derived from precipitation or condensation (Goff et al. 1985; Trainer et al. 2000). The Valles geothermal system is in the central and western parts of the Valles Caldera but does not extend under the entire caldera (Hulen and Nielson 1986; Wilt and Vender Harr 1986).

The caldera contains both thermal and non-thermal groundwater. Like the local surface water drainage patterns, groundwater flows radially outward from the rim of the caldera. The most extensive and productive aquifer in the region underlies the Pajarito Plateau on the east side of the mountain mass. On the west side, thermal and non-thermal waters discharge from the caldera to the southwest, down Cañon de San Diego, which follows the trace of the Jemez Fault Zone. The principal geothermal reservoir, or aquifer, in the region is under the central and western parts of the caldera (Trainer et al. 2000).

Non-thermal water in Valles Caldera occurs in diverse perched aquifers and deeper valley-fill aquifers. The non-thermal groundwater is derived from precipitation or condensation (Vuataz and Goff 1986). Discharge of non-thermal water from Valles Caldera takes several paths, some of which are not well understood. Some of the non-thermal groundwater discharges from springs, particularly from higher, smaller perched aquifers. Water from the more extensive valley-fill aquifers discharges as spring flow and seepage to the principal streams. Some deeper discharge from the valley-fill aquifers recharges the underlying geothermal reservoir by slow leakage through relatively impermeable rocks and along fractures and faults (Faust et al. 1984, in Trainer et al. 2000; Vuataz and Goff 1986, in Trainer et al. 2000). The water that recharges the geothermal reservoir moves downward from the aquifers in the caldera fill to depths of 6,500 feet or more, reaching temperatures of approximately 330 degrees Celsius (°C). This now heated geothermal water then rises convectively to depths of 2,000 feet or less and mixes with other groundwater as it flows away from the geothermal reservoir.

The principal reservoir of geothermal fluids is at depth under the central and western parts of the caldera. The heated water of the geothermal system flows out the caldera to the west and southwest under the Jemez Plateau and along the Jemez Fault Zone. This geothermal water mixes with other groundwater as it flows along the fault zone, and some of this mixed or derivative water issues as hot springs in Cañon de San Diego (Trainer 1974). Outflowing mineral water appears to be limited to the western and southwestern parts of the Jemez Mountains.

The geothermal system at Valles Caldera is subdivided into the Redondo, Sulphur Springs, and Jemez Springs geothermal areas, based on the distribution of springs and fumaroles,[5] past geothermal exploration projects, and scientific drilling programs. Surface discharges at Redondo and Sulphur Springs are fed by upwelling fluids from chemically distinct, isolated reservoirs beneath the caldera floor (OpenEI 2016). Free gas issues at Sulphur Springs and from smaller springs and fumaroles in the resurgent dome of the caldera (Goff et al. 1988). The Jemez Springs system lies outside the caldera walls, to the southwest in Cañon de San Diego. Hydrothermal features outside Valles Caldera are restricted largely to this canyon; geothermal waters reach the springs primarily by structurally controlled lateral outflow and by more minor flow through Paleozoic strata.

Subsurface escape of reservoir fluid from near and beneath Valles Caldera has formed a discharge plume of reservoir water, mixed with dilute groundwater, which extends down Cañon de San Diego (Trainer 1974; Goff et al. 1988). The Jemez Fault Zone transports a relatively large portion of this flow. Soda Dam and Jemez Springs are derivatives of geothermal outflow from the reservoir. Near Jemez Pueblo, subsurface mineral water merges with the regional aquifer in fill deposits of the Albuquerque Basin (Trainer 1974). Free gas also emerges from several thermal features along the Jemez fault zone, southwest of the caldera.

Natural Geothermal Features

Hot springs are found both inside and outside of the Valles Caldera, a result of deep groundwater circulating over the very hot rocks of the magma chamber that underlies the caldera (New Mexico Natural History 2015). Numerous natural mineral hot springs are located throughout the Jemez valley. Some are on public land, others are on private land and are open to the public for a fee. All of these features are found in the Jemez Watershed and are associated with the collapsed caldera. The five natural hot or warm springs in the project area are Jemez, Soda Dam, San Antonio, Spence, and McCauley. An additional hot spring, Sulphur Spring, is just outside of the project area boundaries, in the Valles Caldera. More information on the individual hot springs can be found in the Soils and Water Specialist Report (Forest Service 2016c).

Non-Thermal Groundwater Sources

Little information is available on groundwater hydrology in the region. However, groundwater is critically important because most of the region's residents depend on it for their domestic water

[5] An opening in or near a volcano that emits hot sulfurous gases

supplies, and periodic shortages occur. Aquifer characteristics in much of the region severely limit groundwater availability.

Groundwater beneath the Rio Chama Watershed

Groundwater in the Mancos shale, an aquiclude,[6] has a low yield, and usually is fair to poor quality for livestock or crops. Groundwater in the igneous rocks and volcanics is usually along fracture zones that are hard to intercept with water wells (NRCS 2011a).

The Rio Chama watershed consists of three different geologic provinces, each containing distinct aquifer systems. The Española Basin province, in the southern part of the watershed and overlapping the project area, consists of Tertiary Period sediments, primarily the Santa Fe Group. These deposits are moderately permeable, contain large amounts of sand and gravel, transmit a fair amount of water, and have a relatively large recharge potential, meaning that the groundwater is easily renewed by percolating surface water. Española Basin aquifers usually yield relatively ample supplies of good quality water (New Mexico Office of the State Engineer 2006).

Shallow alluvial aquifers are found throughout the watershed, in all three geologic provinces, and many wells in the region draw water from these aquifers. Alluvial aquifers, composed largely of gravel and sand, can be a good source of water if the deposits are deep and extensive. However, in the Rio Chama region, the alluvial deposits are shallow and generally not extensive. Wells drawing water from these aquifers often run short of water in dry years.

Additional groundwater production may be possible on a limited scale in certain areas. However, in the Rio Chama watershed as a whole, there do not appear to be significant untapped groundwater sources that could replace any large fraction of surface water use or provide major new water supplies in or outside of the region.

Groundwater beneath the Jemez Watershed

The bedrock geology in the western portion of the watershed is characterized by Precambrian metamorphic and Permian sedimentary rocks, while the central and eastern portions of the watershed are composed of volcanic rocks associated with the Valles Caldera. Groundwater occurs in bedrock and in surficial deposits overlying it. Groundwater in the igneous rocks and volcanics is usually along fracture zones that are hard to intercept with water wells. Groundwater quality ranges from fair to poor for livestock or crops (NRCS 2011c).

Groundwater beneath the Rio Grande-Santa Fe Watershed

The most significant aquifer in the Rio Grande-Santa Fe Watershed is the Santa Fe Group, particularly its lower member, the Tesuque Formation. The upper member, the Ancha, is typically more conductive than the Tesuque but occurs above the water table in much of the Rio Grande-Santa Fe Watershed (NRCS 2011b). Deeper groundwater is nearly continuous in the Tesuque Formation throughout the watershed area, to depths of 2,000 feet or greater in some areas. This deep groundwater dates from the Ice Age and is recharged little if at all by present-day rainfall and snowmelt.

Precipitation in the high mountains and flow in the Santa Fe River and its tributary arroyos seeps into and recharges shallow groundwater, which, in some areas, may be continuous with deeper

[6] A subsurface rock, soil, or sediment unit that does not yield useful quantities of water

groundwater (NRCS 2011b). Volcanics often serve as a “floor” or channel to concentrate percolating groundwater and cause it to emerge as spring flow.

3.9.2 Environmental Consequences

3.9.2.1 Scoping Comments on Resource

The following issues specific to water resources were identified during the public scoping period:

- How would geothermal leasing affect surface and subsurface water quantity? Would geothermal leasing change or reduce water allocations for other uses? What are the short- and long-term impacts on the regional aquifer?
- How would geothermal leasing affect water quality, and what size buffers are necessary to protect surface waters? How might these impacts differ, depending on the type of geothermal system?
- How would geothermal leasing affect the Abiquiu Reservoir and Dam and the NMDGF Habitat Stamp Program water projects?

3.9.2.2 How Resource Impacts Were Evaluated

Method

This section analyzes water resource data for the project area to determine the current conditions of watersheds and their susceptibility to impacts from erosion. Water quality, flow pattern, water temperature, and groundwater supply impacts are discussed.

The surface water layers were taken from the NHD Stream and Water Body GIS layers. This dataset represents the drainage network, with such features as rivers, streams, canals, lakes, ponds, coastlines, dams, and stream gages. This dataset has a scale of 1:24,000. These data are designed to be used in general mapping and in analyzing surface water systems.

The watershed boundaries were delineated by the NRCS Geospatial Data Gateway. Both fourth- and sixth-level watershed boundaries from this dataset are used. The watershed erodibility index analysis uses the Kw factor from the State Soil Geographic spatial database and land slope derived from USGS 30-meter digital elevation models. The Watershed Condition Class Framework is from the Forest Service GIS Layer. The 100-year floodplains are from the Federal Emergency Management Act GIS layer. The well data is from the NMOSE Enterprise GIS.

The NMOSE Enterprise GIS offers an open data site, which is set up for agency transparency for allowing the public and other agencies access to downloadable data from the NMOSE. The point of diversions layer includes well locations, surface declarations, and surface permits. These data were extracted from the NMOSE Water Administration Technical Engineering Resource System database. These data are current as of March 2016, have varying degrees of accuracy, and have not been validated.

Indicators

Indicators of the impacts of the proposed action and alternatives are as follows:

- Erosion and sedimentation that could alter or impair perennial or intermittent streams; the analysis includes a combined erosion and transport potential for each watershed in the project area, as measured by the soil erosion water factor (Kw) and slope to form the watershed erodibility index

- Possible impacts on beneficial uses and sensitive watersheds as measured by combining factors including the watershed erodibility index, watershed condition class, impaired streams, density of roads and beneficial uses
- Potential for contamination of fresh surface water or groundwater supplies, as indicated by risk of leaks and spills
- Possibility for depletion of groundwater supplies or interferences with groundwater recharge, such that the local groundwater table would be lowered to a level that would not support existing land uses
- Potential for groundwater “mounding” due to injection that does not result in groundwater being returned to the aquifer that it was extracted from
- Potential for changes to natural thermal features
- Potential for changes in flow from springs and in surface water drainages
- Potential for changes in groundwater or surface water temperatures
- Potential for changes in groundwater or surface water quality
- Potential for changes in source water and vegetation at wetland areas
- Possible flash flooding impacts on proposed facilities, as indicated by location of 100-year floodplains

Assumptions

This analysis assumes the following:

- Leasing land does not involve ground-disturbing activities or any type of construction, so there would be no direct impact on water resources. Impacts would result from activities pursued after leasing.

3.9.2.3 Common Impacts Associated with Geothermal Development

The following impact analysis provides a general description of common impacts on water resources from geothermal development, as well as specific impacts based on the RFDS. Because the RFDS is the same under all alternatives, except the No Leasing Alternative (Alternative 3), general impacts under those alternatives would be the same.

The information presented in the Common Impacts on Water Resources and Quality Associated with Geothermal Development section of the 2008 Geothermal PEIS is incorporated by reference and summarized here. As described in the 2008 Geothermal PEIS, common impacts from geothermal development could include water contamination, lowered groundwater tables, and changes in water temperature.

Impacts on water quantity are directly related to water use. Water use would occur for drilling wells, constructing infrastructure, stimulating injection wells, operating the power plant, and dust control. Water would not be used for cooling because the air temperature is sufficiently low to allow for air cooling of water to be reinjected. The applicant would be responsible for obtaining water rights in accordance with state and federal regulations. Fresh water used in the drilling operations would be trucked in or would come from local springs and wells at depths less than 1,000 feet (BLM 2015). Water is used during the well construction as drilling fluids, and for cementing the casing in place. Well depth, total number of wells, volume of the borehole, and the physical and chemical properties of the formation would affect water volume requirements during drilling operations.

For enhanced geothermal systems, water is also required for stimulating the reservoir[7]. Stimulation volume is dependent on the desired water volume flow rate (Clark et al. 2011). The vast majority of water use would occur during the operations phase. Although extracted water would be reinjected after use, water may be lost to the geologic formation. To maintain pressure and operation, water that is lost must be made up from alternative water sources. Water consumption (i.e., water that is withdrawn from a resource such as a river, lake, or non-geothermal aquifer that is not returned to that resource), varies between 0.29 and 0.72 gallon per kilowatt-hour for enhanced geothermal scenarios (Clark et al. 2011).

Potential impacts on surface water quality due to ground disturbance during road, powerline, and facility development could occur from erosion and subsequent transport of eroded materials into surface waters in areas where vegetation has been removed and soils disturbed. This could increase suspended sediment and turbidity in surface water following periods of runoff. There could also be impacts on sensitive riparian zones due to road construction and any activities that are proposed near stream courses. This would be of particular concern in areas of highly erodible soils, near impaired stream reaches, or in sensitive watersheds.

Potential short-term impacts on water quality could also occur from accidental releases of chemical compounds, such as fuels, solvents for removing buildup on pipes, and working fluids required for drilling and operation activities, or wastewater, which could contaminate surface water and shallow groundwater. Impacts from accidental releases of wastewater, such as stormwater or sanitation water, could include increased concentrations of nitrate, phosphate, total dissolved solids, and fecal coliform in shallow groundwater or surface water. The risk of occurrence of spills, or impacts if a spill occurs, would be reduced by incorporating in the development plan BMPs and environmental protection measures. Extracted geothermal fluids containing high concentrations of dissolved constituents and leaking into the shallow aquifer could contaminate freshwater supplies through faulty reinjection practices, geothermal well casing failure, and uncontrolled discharge of waste geothermal fluids. Protecting groundwater from contamination by geothermal fluids is facilitated by the use of multiple casing strings, whose depths are specified partly on the basis of the depths of groundwater aquifers. In addition, redundant blow-out prevention equipment is used.

Impacts would vary relative to the area that is disturbed and location of the disturbance in relation to permeable soils and local aquifers.

Binary power plant systems would return most of the extracted groundwater to the geothermal source aquifer through injection wells. During pumping, some groundwater flow paths in the deeper aquifers could be modified due to reductions in temperature of reinjected waters, which reduces pressure in the deeper geothermal system and could therefore change flow paths. Upward vertical hydraulic gradients could be reduced due to this depressurization, altering flow paths. It is also possible that the reinjection site would not return the geothermal fluid to the exact hydraulic connection that it was withdrawn from, and water may be lost to the formation. This could also locally alter pressurization in the system and flow paths. Monitoring plans could be implemented to track changes occurring from the pumping.

[7] Stimulation opens existing spaces within the formation and enables or enhances the circulation of fluids.

Flows at non-thermal springs and seeps are not likely to be affected by geothermal groundwater development. Most of these springs are recharged by shallow groundwater with short flow paths, which is recharged primarily from precipitation, irrigation, and runoff. For most of the project area, geothermal fluids would be extracted at much greater depths than the shallow aquifer and would be reinjected once the heat is extracted. However, there are numerous faults extending from the caldera, and where there is an interconnection between deeper groundwater and faults, pumping could change flow paths. There also could be some slight changes in flow paths from pressure differences due to small differences in the extraction and reinjection zones.

Deeper groundwater is nearly continuous in the Tesuque Formation throughout the Santa Fe-Rio Grande Watershed area, to depths of 2,000 feet or greater in some areas. This deep groundwater dates from the Ice Age, approximately 10,000 years ago, and is recharged little if at all by present-day rainfall and snowmelt. Should geothermal extraction occur in this area, there could be more risk of changes to flow paths, and mixing of geothermal fluids with other groundwater. However, as geothermal waters are reinjected, any changes in groundwater level would be minor and would result from changes in flow paths, rather than reductions in groundwater quantity.

Where there is interconnected flow to springs and seeps in thermal areas, this could alter the mixing of weather-related non-thermal waters with the deeper geothermal waters and alter flow paths to geothermal features. Additionally, temperatures could be lowered if interconnected flow from deeper zones is reduced by returning the cooled geothermal water to the reservoir.

3.9.2.4 Impacts Under Alternative 1

Alternative 1 would have the same general impacts on water resources associated with the RFDS described under *Common Impacts Associated with Geothermal Development*, above. Although the SFNF would not make an availability determination for geothermal leasing in the project area, geothermal lease applications and nominations would continue to be processed on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan (Forest Service 1987) and existing laws and regulations.

Geothermal leasing stipulations and closures would not be specifically implemented related to watershed, surface water, or groundwater resources; however, any future geothermal lease applications and nominations would be subject to standards and guidelines outlined in the Forest Plan and environmental analysis.

It has been established that there is a geothermal plume that extends from the caldera southwest to Jemez Springs and Soda Dam. The delineation of that plume is not exact. Most of it likely runs through the JNRA Unit, which is not available for leasing. However, the plume may also extend into the Middle Unit and South Unit, west of the edge of the caldera. Any pumping, including outside of the geothermal system, could affect pressurization, temperature, and possible flow paths.

The hot springs in Valles Caldera and southwest of the caldera in San Diego Canyon could be impacted by extracting and reinjecting geothermal waters from these systems. Both flow rates and water quality could be impacted. Extracting groundwater could have short-term impacts in reducing shallow groundwater levels and altering pressures of geothermal sources and fractures.

Because the applicant would be required to obtain water rights, and the source of makeup water is unknown, the amount of water consumption occurring within the project area is unknown.

3.9.2.5 Impacts Under Alternative 2

Under Alternative 2, indirect impacts from anticipated geothermal exploration and development would generally be the same as those described under Alternative 1, although the location of potential sites would be restricted by administrative withdrawals and stipulations. Approximately 32,000 acres, or 17 percent of the NFS lands in the project area, would be closed to geothermal leasing, while approximately 136,650 acres in the project area would be allocated as open to geothermal leasing, subject to existing laws, regulations, formal orders, and stipulations.

NSO stipulations for drinking water sources, points of surface water diversions, developed springs and wells, rivers, streams, wetlands, springs, playas, riparian areas, 100-year floodplains, and other water bodies would reduce the potential for direct impacts on these resources from erosion caused by development and contamination from accidental spills. Implementing a 1-mile no leasing protection zone around geothermal features should reduce the potential for direct pumping of geothermal fluids around these features. However, in this fractured and interconnected system, pumping some distance from the geothermal features could change temperature and chemical composition and flow rates.

NSO stipulations on slopes greater than 40 percent and soils with severe erosion potential, as well as CSU stipulations for slopes between 30 and 40 percent, would reduce the potential for direct impacts on water resources connected with these sites from erosion caused by development and contamination from accidental spills. However, road and power line development could still impact all of these areas, as described under *Common Impacts Associated with Geothermal Development*.

Because the applicant would be required to obtain water rights, and the source of makeup water is unknown, the amount of water consumption occurring within the project area is unknown. However, BMPs—such as evaluating the consumptive use of water in the operation and its effect on water dependent ecosystems, and identifying areas of groundwater discharge and recharge and their potential relationship with surface water bodies—could be applied into the permit application or included as approved use authorizations by the BLM as COAs. These measures would reduce the likelihood of lowering the groundwater table to a level that would not support existing land uses.

There would be no indirect impacts on surface water in the Valles Caldera National Preserve or Bandier National Monument. This is because surface water drainage from the caldera generally flows into the project area. While headwaters to perennial streams in the South Unit of Bandelier National Monument occur in the south unit of the project area, no impacts on these headwaters are anticipated. This is because NSO stipulations would apply to 33,200 acres in the south unit (or 97 percent of the south unit), including 500 feet from the outer edge of perennial and intermittent rivers and streams.

3.9.2.6 Impacts Under Alternative 3

There would be no direct impacts on watersheds or groundwater resources under Alternative 3. No surface areas would be disturbed by geothermal developments; however, there would be indirect impacts on water resources. Because the area would be closed to leasing for the foreseeable future, over time, there would be less potential impacts on surface or subsurface water resources than expected under implementation of the current Forest Plan.

3.9.2.7 Impacts Under Alternative 4

Impacts from Alternative 4 would be similar to those described under Alternative 2. However, there would be no discretionary closures under Alternative 4, and there would be reduced protection of specific areas from implementing less restrictive lease stipulations.

Although there would be no discretionary closures, approximately 17 percent of the NFS lands in the project area would still be closed to geothermal leasing. NSO would still be stipulated for slopes in excess of 40 percent, and slopes between 30 and 40 percent would still be subject to CSU. However, implementing CSU rather than NSO stipulations on areas with severe erosion hazard would increase the risk of erosion in areas disturbed by exploration and development of geothermal sites. This would increase sedimentation and turbidity into streams and rivers, particularly near steeper slopes between 30 and 40 percent and areas with moderately high to high runoff potential.

Runoff from development on steep slopes in areas of severe erosion hazard would be a concern for watersheds and water quality if runoff were to reach streams and impact water quality. BMPs identified in Appendix C could be implemented to minimize and contain erosion.

CSU rather than NSO stipulations in intermittent streams (the NSO still holds for perennial streams) would increase the risk of erosion and transport to water sources. This would be the case particularly in areas of severe erosion hazard and where the runoff potential is moderate to high. Implementing an additional CSU stipulation for ephemeral drainages would reduce the risk of erosion and sediment transport in these areas. BMPs identified in Appendix C could be implemented to help reduce impacts on these stream reaches.

Impacts from road development and water use under Alternative 4 would be the same as those described under Alternative 2.

Under Alternative 4, NSO stipulations apply to natural geothermal features, and a 1-mile buffer around them. NSO stipulations would protect these resources from accidental spills or leaks from the pumping site and would increase the difficulty of accessing geothermal waters close to the geothermal features. However, this stipulation does not prevent withdrawals from waters near the geothermal features using advanced technology. A lessee of a NSO area must develop any surface infrastructure outside the NSO area and would need to use advanced technology, such as directional drilling, to access the geothermal resource under the NSO area; nevertheless, those resources could still be accessed. Therefore, this alternative is more likely to impact natural geothermal features, potentially affecting temperatures and flow rates. BMPs identified in Appendix C include a monitoring plan, which could be implemented to identify impacts on these resources.

There would be no indirect impacts on surface water in the Valles Caldera National Preserve or Bandier National Monument because surface water drainage from the caldera generally flows into the project area. While headwaters to perennial streams in the South Unit of Bandelier National Monument occur in the south unit of the project area, no impacts on these headwaters are anticipated. This is because NSO stipulations would apply to 33,200 acres in the south unit (or 97 percent of the south unit).

3.9.2.8 Cumulative Impacts

Cumulative impacts for water resources are analyzed at the level of the sixth-level watersheds. Past, present, and reasonably foreseeable future actions are discussed in **Section 3.3.4**.

Water resource repair and replacement projects—the Pueblo of Jemez Red Rocks Dam Repair, the Abiquiu Land Grant Waterline Replacement, and the McKinney County Dam—in combination with Alternatives 1, 2, and 4, would likely initially directly impact water resources through increased erosion and sedimentation into waterways. However, long-term impacts would be improved protection from flooding and erosion and reduced potential for loss of water resources through leakage.

Restoration projects, such as the Southwest Jemez Mountains Restoration Project, Pueblo of Jemez Owl Springs Bridge Sediment Removal Project, and Valle Seco Wetland Restoration Project, would maintain or improve water resource conditions in their respective project areas by removing sedimentation and reducing erosion, or by maintaining streambank stability.

Under Alternatives 1, 2, or 4, sedimentation and erosion would likely occur from geothermal development. Natural processes, such as fire, could accelerate or amplify the impacts of sedimentation and erosion. The magnitude and intensity of these impacts would depend on the size and severity of the fire, as well as local soil conditions. Water quality impacts from accidental spills related to geothermal development are possible and could be combined with impacts from sediment transport and erosion or other accidental spills outside of the project area that travel downstream through the sixth-level watersheds.

Although extracted water would be reinjected after use, water may be lost to the geologic formation. To maintain pressure and operation, water that is lost must be made up from alternative water sources, which may contribute to the cumulative demand for water resources in the fourth-level watersheds under Alternatives 1, 2, and 4. While the source of makeup water is unknown, BMPs identified in Appendix C—such as evaluating the consumptive use of water in the operation and its effect on water dependent ecosystems, and identifying areas of groundwater discharge and recharge and their potential relationship with surface water bodies—could be applied into the permit application or included as approved use authorizations by the BLM as COAs. These measures would reduce the likelihood of lowering the groundwater table to a level that would not support existing land uses.

3.10 Air Quality and Air Quality-Related Values

3.10.1 Affected Environment

Ambient air quality is affected by the type and amount of air pollutants emitted into the atmosphere, the size and topography of the air basin, prevailing meteorological conditions, and the conversion of air pollutants and other species by a complex series of chemical and photochemical reactions in the atmosphere. The levels of air pollutants are generally expressed in terms of concentration, either in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter (µg/m).

3.10.1.1 Regulatory Framework

Clean Air Act

The Clean Air Act (CAA; 42 USC, Sections 7401-7642), as amended, is the primary authority for regulating and protecting air quality in the United States. The EPA has the primary responsibility for regulating atmospheric emissions. This includes six nationally regulated air pollutants, known as criteria pollutants, that are believed to be key indicators of air quality: carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead, and two categories of particulate matter (particulate matter with an aerodynamic diameter of 10 microns or less [PM_{10}] and particulate matter with an aerodynamic diameter of 2.5 microns or less [$PM_{2.5}$]).

Under the authority of the CAA, the EPA has set time-averaged national ambient air quality standards (NAAQS) for these criteria pollutants. The two-tiered standards may be primary or secondary. Primary standards set limits to protect public health, including the health of sensitive populations, such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. Averaging periods vary by pollutant, based on the potential health and welfare impacts of each pollutant. States may set their own ambient air quality standards, but they must be at least as stringent as the national standards. National and state ambient air quality standards are shown in **Table 3-5**, below.

Table 3-5. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	National Standards			New Mexico Standard
		Primary	Secondary	Form	
Ozone	8-hour	0.070 ppm[1]	Same as primary	Annual 4th-highest daily maximum 8-hour concentration, averaged over 3 years	—
Carbon monoxide	8-hour	9 ppm	—	Not to be exceeded more than once per year	8.7 ppm
	1-hour	35 ppm	—		13.1 ppm
Nitrogen dioxide	Annual (arithmetic mean)	0.053 ppm	Same as primary	Annual mean	0.05 ppm
	24-hour	—	—	—	0.10 ppm
	1-hour	100 ppb	—	98th percentile, averaged over 3 years	—
Sulfur dioxide	Annual mean	—	—	—	0.02 ppm
	24-hour	—	—	—	0.10 ppm
	3-hour	—	0.5 ppm	Not to be exceeded more than once per year	—
	1-hour	75 ppb[2]	—	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years	—
PM_{10}	24-hour	150 µg/m^3	Same as primary	Not to be exceeded more than once per year on average over 3 years	—
$PM_{2.5}$	Annual (arithmetic mean)	15 µg/m^3	Same as primary	Annual mean, averaged over 3 years	—
	24-hour	35 µg/m^3	Same as primary	98th percentile, averaged over 3 years	—
Lead[3]	Rolling 3-month average	0.15 µg/m^3	Same as primary	Not to be exceeded	—

Table 3-5. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	National Standards			New Mexico Standard
		Primary	Secondary	Form	
Total suspended particulates	Annual (geometric mean)	—	—	—	60 µg/m^3
	30-day average	—	—	—	90 µg/m^3
	7-day	—	—	—	110 µg/m^3
	24-hour	—	—	—	150 µg/m^3
Total reduced sulfur	0.5-hour	—	—	—	0.003 ppm
Hydrogen sulfide	1-hour (statewide)	—	—	—	0.010 ppm
	0.5-hour (within 5 miles of municipalities greater than 20,000 people)	—	—	—	0.003 ppm
Total reduced sulfur	0.5-hour	—	—	—	0.003 ppm

Sources: EPA 2016a; New Mexico Commission of Public Records 2002

[1]Final rule signed October 1, 2015, and effective December 28, 2015. The 2008 ozone standards additionally remain in impact in some areas. Revocation of the 2008 ozone standards and transitioning to the 2015 standards will be addressed in the implementation rule for the current standards.

[2]Final rule signed June 2, 2010. The 1971 annual and 24-hour sulfur dioxide standards (0.03 ppm annual and 0.14 ppm 24-hour) were revoked in that same rule making. However, these standards remain in impact until one year after an area is designated for the 2010 standard. One exception is in areas designated nonattainment for the 1971 standards; here, the 1971 standards remain in impact until implementation plans to attain or maintain the 2010 standard are approved.

[3]Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m^3) remains in impact until one year after an area is designated for the 2008 standard. The one exception is in areas designated nonattainment for the 1978 standard; here, the 1978 standard remains in impact until implementation plans to attain or maintain the 2008 standard are approved.

Hazardous Air Pollutants

Congress amended the CAA in 1990 to address a large number of air pollutants that are known to cause or may reasonably be anticipated to cause impacts on human health or the environment. Congress initially identified 188 specific pollutants and chemical groups as hazardous air pollutants and has modified the list over time.

The CAA requires control measures for hazardous air pollutants. The EPA issues national emissions standards for hazardous air pollutants to limit the release of specified hazardous air pollutants from specific industrial sectors. These standards are technology based, meaning that they represent the maximum achievable control technology that is economically feasible for an industrial sector. The CAA defines a major source for hazardous air pollutants to be one that emits 10 tons per year of any single hazardous air pollutant or 25 tons per year of any combination of hazardous air pollutants. Under state regulations, a construction or operating permit may be required for any major source, though some exceptions apply. In New Mexico, these regulations are Sections 20.2.70 and 20.2.73 of the New Mexico Administrative Code.

Clean Air Act Conformity Requirements

Section 176(c) of the CAA requires that federal actions conform to the appropriate state implementation plan. This is a plan developed at the state level that provides for the implementation, maintenance, and enforcement of NAAQS and is enforceable by the EPA. The EPA has promulgated rules establishing conformity analysis procedures for transportation-related actions and for other general federal agency actions (40 CFR, Parts 6, 51, and 93).

The EPA general conformity rule requires preparation of a formal conformity determination document for federal agency actions that are undertaken, approved, or funded in federal nonattainment or maintenance areas, when the total net change in direct and indirect emissions of nonattainment pollutants (or their precursors) exceeds specified thresholds. Because the SFNF Ranger Districts in the project area are not in a nonattainment or maintenance area, the proposed action is exempt from the CAA general conformity rule (discussed further under *Air Quality Conditions*, below).

Prevention of Significant Deterioration

In addition to the NAAQS, the Prevention of Significant Deterioration (PSD) regulations set forth a permit process that applies to new major sources or major modifications of existing sources for pollutants. It is applicable where the emission source is inside an attainment or unclassifiable area, as defined by the NAAQS. Furthermore, the PSD program requires the use of best available control technologies and provides for an air quality impact analysis and public involvement. The purpose of the PSD program is to protect public health and welfare. It also preserves, protects, and enhances the air quality of national parks and wilderness areas, national monuments, seashores, and other areas of recreation, scenic, or historic value.

The PSD regulations prevent areas that are in attainment of the NAAQS from being polluted up to the level of the standards. The CAA directs the EPA to classify areas of the United States as Class I, II, or III. Class I areas are national parks and wilderness areas of a certain size that existed before 1977 or additional areas that have since been designated by federal regulation. The PSD regulations place limits on the total increase in ambient pollution levels above established baseline levels for sulfur dioxide, nitrogen dioxide, and PM_{10} that are allowed in these areas. Class II areas are the remaining areas in the United States (outside of nonattainment and maintenance areas). No Class III areas have been designated.

The SFNF is not a PSD Class I area. There are four Class I areas within 62 miles of the SFNF boundary: Bandelier Wilderness, Pecos Wilderness, San Pedro Parks Wilderness, and Wheeler Peak Wilderness.

The PSD regulations require operators of major sources or major modification of sources to obtain permits for attainment pollutants. Geothermal plants are not a rule-listed emissions source; therefore, the PSD trigger levels are 250 tons per year for each criteria pollutant emitted during individual plant operations.

Regional Haze Rule

On July 1, 1999, the EPA issued regional haze rules to comply with the requirements of the CAA. Under 40 CFR, Subpart 51.308, the rule requires the State of New Mexico to develop state implementation plans. The plans must include visibility progress goals for each of the nine Class I areas in New Mexico, as well as provisions requiring continuing consultation between the state and federal land managers to address and coordinate implementation of visibility protection programs. Under 40 CFR, Subpart 51.309, the rule also provides an optional approach to New

Mexico and eight other western states to incorporate emission-reduction strategies issued by the Grand Canyon Visibility Transport Commission. These are designed primarily to improve visibility in 16 Class I areas on the Colorado Plateau, including the San Pedro Parks Wilderness Area (Forest Service 2015d). New Mexico has been implementing an approved state implementation plan since 2006. The goal of the regional haze rule is, by 2064, to return visibility in Class I areas to visibility conditions before man-made impacts.

State Law

In New Mexico, the Environmental Improvement Board is the state air pollution control agency (except in Bernalillo County), and air quality programs are administered under the authority of the NMED. Air quality is regulated under the New Mexico Air Quality Control Act (Sections 74-2-1 to 74-2-17, New Mexico Statutes, Annotated 1978) and the New Mexico Ambient Air Quality Standards and Air Quality Control Regulations.

The state ambient air quality standards are described in **Table 3-5**. One of the state-regulated pollutants, hydrogen sulfide, is a naturally occurring byproduct of oil, gas, and geothermal development in some areas. It is a colorless flammable gas with a rotten egg smell. It is both an irritant and a chemical asphyxiant, with impacts on both oxygen utilization and the central nervous system. Its health impacts can vary, depending on the level and duration of exposure. While there is no NAAQS for hydrogen sulfide, and it is not regulated as a hazardous air pollutant under the CAA, a number of states, including New Mexico, have set standards for hydrogen sulfide at the state level. No information was found on whether hydrogen sulfide is present, or at what levels, in geothermal fluids in the project area.

3.10.1.2 Air Quality Conditions

The CAA requires each state to identify areas that have ambient air quality in violation of federal standards using monitoring data collected through state monitoring networks, as follows:

- Areas that violate air quality standards are designated as nonattainment for the relevant criteria air pollutants.
- Areas that comply with air quality standards are designated as attainment for the relevant criteria air pollutants.
- Areas that have been re-designated from nonattainment to attainment are considered maintenance areas.
- Areas of uncertain status are generally designated as unclassifiable but are treated as attainment areas for regulatory purposes.

The project area is in attainment or unclassified for all NAAQS (EPA 2016b). The only nonattainment and maintenance areas are in southwestern New Mexico, over 200 miles south of the project area. Given the distance between these nonattainment and maintenance areas and the weather patterns in New Mexico, the proposed action would have no potential to affect air quality in these areas; thus, these areas would have no potential to affect air quality in the project area.

The NMED, Air Quality Bureau, is responsible for operating a network of air monitoring stations in most of New Mexico. **Table 3-6**, below, shows the locations, the pollutants monitored, and the last three years of monitoring data for each station in Rio Arriba and Sandoval Counties.

Table 3-6. Air Quality Monitoring Values in Rio Arriba and Sandoval Counties, New Mexico

Pollutant	Averaging Time	2012	2013	2014	3-Year Average	NAAQS	Percent of NAAQS
Coyote Ranger District (21 New Mexico 96, Coyote, NM 87012; Rio Arriba County)[1]							
Ozone (ppm)	8-hour	N/A[2]	0.066 ppm	0.065 ppm	N/A[2]	0.070 ppm	N/C[3]
Highway Department Yard Near Bernalillo (E Avenida Bernalillo, Bernalillo, NM; Sandoval County)[4]							
Ozone (ppm)	8-hour	0.062 ppm	0.067 ppm	0.062 ppm	0.064 ppm	0.070 ppm	91
Bernalillo City Hall (829 S Camino Del Pueblo, Bernalillo, NM 87004; Sandoval County)[5]							
PM_{10} (μg/m^3)	24-hour	23 μg/m^3	25 μg/m^3	21 μg/m^3	23 μg/m^3	150 μg/m^3	15

Source: EPA 2016c
[1]Approximately 2 miles northwest of the project area boundary
[2]Not available
[3]Not calculated since there are not three consecutive years of data
[4]Approximately 25 miles south of the project area boundary
[5]Approximately 30 miles south of the project area boundary

As shown in **Table 3-6**, ambient air concentrations of monitored pollutants are below the NAAQS for stations with three consecutive years of data. However, monitored levels of ozone are nearing the NAAQS. These ozone levels generally are attributed to oil and gas operations and power plants, including the San Juan Generating Station and the Four Corners Power Plant, in the region (Four Corners Air Quality Task Force 2007).

Actions to address emissions from oil and gas operations and fossil fuel-fired power plant operations have included the following:

- In October 2012, the EPA promulgated New Source Performance Standards under 40 CFR, Part 60, Subpart OOOO, that requires air pollution controls for volatile organic compounds at natural gas production wells and other facilities associated with the oil and gas industry.
- In 2013, the NMED, the Public Service Company of New Mexico, and the EPA agreed to meet the requirements of the federal regional haze rule by closing two units at the San Juan Generating Station by the end of 2017.
- In December 2013, three coal-fired generators were closed at the Four Corners Power Plant as part of a plan to meet the requirements of the federal regional haze rule. The remaining two coal-fired generators will have selective catalytic reduction technology installed by 2018. These changes satisfy the EPA’s best available retrofit technology requirements.

It is uncertain whether the Four Corners area will be redesignated as an ozone nonattainment area over the 15-year life of the RFDS (2016 to 2031), or if the SFNF will be included in the nonattainment boundary if redesignation occurs. While federal, state, local, and tribal jurisdictions continue to seek ways to reduce emissions from the oil and gas sector and electricity generating plants through voluntary and regulatory mechanisms, sources of ozone-precursor emissions from these industrial sectors continue to be proposed west of the project area.

Existing Emissions

The EPA prepares a national emissions inventory every three years to provide a comprehensive and detailed estimate of emissions from all air emission sources in the United States. Emissions in the inventory are presented by county. The inventories are based on emission estimates and model inputs provided by state, local, and tribal air agencies for sources in their jurisdictions, supplemented by data developed by the EPA.

Table 3-7, below, summarizes the mobile and stationary source emissions in Rio Arriba and Sandoval Counties in 2011, the most recent inventory year available (EPA 2013). This baseline emissions summary is a conservative overestimate of project area emissions. This is because it includes emissions from all of Rio Arriba and Sandoval Counties, and the project area encompasses only approximately 3 percent of those counties together. However, the baseline emissions summary provides a scale against which to compare projected emissions from geothermal exploration, development, and production under the proposed action.

Table 3-7. Summary of Annual Emissions for Rio Arriba and Sandoval Counties, 2011 (Tons)

Source Category County	Volatile Organic Compounds	Carbon Monoxide	Nitrogen Oxides	Sulfur Dioxide	PM_{10}	$PM_{2.5}$
Agricultural						
Rio Arriba	—	—	—	—	34	7
Sandoval	—	—	—	—	36	7
Subtotal	—	—	—	—	*70*	*14*
Bulk Gasoline Terminals and Gas Stations						
Rio Arriba	303	—	—	—	—	—
Sandoval	591	—	—	—	—	—
Subtotal	*894*	—	—	—	—	—
Commercial Cooking						
Rio Arriba	1	3	—	—	7	7
Sandoval	4	11	—	—	29	26
Subtotal	*5*	*14*	—	—	*36*	*33*
Dust						
Rio Arriba	—	—	—	—	32,819	308
Sandoval	—	—	—	—	38,616	3,949
Subtotal	—	—	—	—	*71,435*	*4,257*
Fuel Combustion						
Rio Arriba	811	2,542	1,811	13	109	106
Sandoval	214	1,296	416	75	209	180
Subtotal	*1,025*	*3,838*	*2,227*	*88*	*318*	*286*
Industrial Processes						
Rio Arriba	15,498	12,411	9,016	4	124	109
Sandoval	525	338	300	0	35	9
Subtotal	*16,020*	*12,749*	*9,316*	*4*	*159*	*118*
Miscellaneous Nonindustrial						
Rio Arriba	19	0	0	0	0	0
Sandoval	36	0	0	0	0	0
Subtotal	*55*	0	0	0	0	0

Table 3-7. Summary of Annual Emissions for Rio Arriba and Sandoval Counties, 2011 (Tons)

Source Category County	Volatile Organic Compounds	Carbon Monoxide	Nitrogen Oxides	Sulfur Dioxide	PM_{10}	$PM_{2.5}$
Mobile Sources						
Rio Arriba	920	6,608	1,108	6	62	49
Sandoval	1,513	15,487	3,397	16	169	129
Subtotal	*2,433*	*22,095*	*4,505*	*22*	*231*	*178*
Solvents						
Rio Arriba	295	—	—	—	—	—
Sandoval	929	—	—	—	—	—
Subtotal	*1,224*	—	—	—	—	—
Waste Disposal						
Rio Arriba	30	366	14	1	67	57
Sandoval	3	4	1	1	11	7
Subtotal	*33*	*370*	*15*	*2*	*78*	*64*
Total source emissions[1]	**21,689**	**39,066**	**16,063**	**116**	**72,327**	**4,950**
Total source emissions (without fugitive dust)	**21,689**	**39,066**	**16,063**	**116**	**892**	**693**

Source: EPA 2013

3.10.1.3 Air Quality-Related Values

AQRVs are resources that may be affected by a change in air quality, including visibility, aquatic and terrestrial impacts of wet and dry pollutant deposition, and terrestrial impacts of ozone. The only AQRV discussed in this report is visibility, which is the primary AQRV concern in the project area and the AQRV with the most potential to be impacted by the proposed action.

In 1985, the EPA initiated a network of monitoring stations to measure impacts on visibility in Class I areas. These are known as the Interagency Monitoring for the Protection of Visual Environments monitors and exist in some, but not all, Class I areas. There are monitors at three of the four Class I areas within 62 miles of the project area; however, one of the monitors represents conditions at both the Pecos Wilderness and Wheeler Peak Wilderness.

The visibility trends for the Interagency Monitoring for the Protection of Visual Environments monitors in Bandelier Wilderness, Pecos Wilderness/Wheeler Peak Wilderness, and San Pedro Parks Wilderness are shown in the Air Technical Report (Forest Service 2016d). The top line on each graph is for the 20 percent worst days, and the bottom line is for the 20 percent best days. A down-sloping line means less reduction of visibility and therefore an improvement. In most cases, visibility trends have been flat or improving. Implementation of best available retrofit technology strategies, as required under the federal Regional Haze Rule, may result in further improvements. The peak in the Bandelier Wilderness 20 percent worst days line is likely due to the occurrence of large wildfires in 2000.

3.10.2 Environmental Consequences

3.10.2.1 Scoping Comments on Resource

The following issues specific to air quality and air quality related values were identified during the public scoping period:

- How would gases and emissions from geothermal leasing be monitored and controlled, and how would residual waste accumulations from air emission management be disposed of?
- What are the impacts of odors from geothermal leasing, and how would these affect receptors in the project area?

3.10.2.2 How Resource Impacts Were Evaluated

Method

The method for air quality impact analysis is incorporated by reference from the 2008 Geothermal PEIS (BLM and Forest Service 2008). There would be no direct impacts on air quality and AQRVs from leasing actions. However, it is reasonable to foresee that on-the-ground impacts would occur if the Forest Service were to consent to leasing and the BLM were to issue geothermal leases.

The potential impacts of geothermal development on air quality and AQRVs were evaluated by examining the typical air emissions associated with the various stages of geothermal development. The emissions from potential geothermal well development were compared against the PSD construction permit threshold. There are no federally designated nonattainment areas in the project area, so CAA conformity guidelines do not apply.

Indicators

The indicators of impacts on air quality are as follows:

- Emissions in tons per year for regulated pollutants
- Comparison to PSD permitting thresholds
- Amount and time frame of steam and water vapor emitted from potential project operations

Assumptions

- BMPs, such as those identified in Appendix C, would be applied, as applicable, at the BLM permitting level to minimize impacts on air quality from exploration, drilling operations, utilization, and reclamation and abandonment.
- State air permitting requirements would depend on the timing, scope, and size of site-specific geothermal exploration, development, and utilization proposals and would be determined during project-level analysis prior to approval.
- Based on existing temperature gradient data, binary cycle power plants (which operate at lower temperatures than flash steam or dry steam plants) are the most likely technology that would be developed in the project area. Therefore, this analysis does not assess the potential impacts of flash steam or dry steam geothermal power plants. Binary plants are closed-loop systems and do not emit air pollutants during their operation. For this reason, only emissions from exploration and development are evaluated.
- Binary plants would use air cooling rather than wet cooling.
- A total of 25 leases would be issued during the 15-year RFDS time frame (2016 to 2031).

- Five 25-megawatt binary power plants would be developed on leases in the project area.
- Total surface disturbance associated with geothermal exploration would be 27 acres.
- Total surface disturbance associated with development drilling and utilization would be 647 acres, including disturbance associated with developing wells, transmission lines, pipelines, roads, power plants, and ancillary facilities.

Geothermal leasing would have no direct impacts on air quality and AQRVs; any impacts would occur from subsequent development activities.

3.10.2.3 Common Impacts Associated with Geothermal Development

This section addresses the general air quality and AQRV impacts associated with each phase of geothermal development. The common impacts associated with exploration, drilling, utilization, and reclamation and abandonment presented in the 2008 Geothermal Programmatic EIS (BLM and Forest Service 2008; Section 4.8.3, Common Impacts on Air Quality and Atmospheric Values Associated with Geothermal Development) are summarized below.

Some activities resulting in air quality emissions are common to all phases of a geothermal project life cycle, while others are specific to certain phases. Table 4-1 in the Geothermal Programmatic EIS (BLM and Forest Service 2008) summarizes the activities and the criteria pollutants of concern related to those activities and are incorporated here by reference.

General Geothermal-Related Air Quality Impacts Associated with Each Phase of Geothermal Development

Exploration

Air quality and AQRV impacts associated with exploration are short term and are generally limited to the release of fugitive dust from surface disturbance and emissions from vehicles and construction and drilling equipment. Initial exploration activities, such as surveying and sampling, would have minimal impacts on air quality and AQRVs. These impacts would be from accessing exploration sites in areas without roads and from disturbing small land areas while placing surveying equipment. Secondary exploration activities, specifically site clearing, exploration well pad development, and drilling temperature gradient wells and slim wells, would have more intensive fugitive dust and exhaust-related emissions and would last longer. The total time for exploration activities typically ranges from one to five years.

Drilling Operations

Air emissions during the drilling operations phase of a geothermal project are fugitive dust and emissions from combustion engines. The following specific activities during the drilling operations phase would result in emissions of fugitive dust and exhaust from combustion engines:

- Driving vehicles, such as worker vehicles, watering trucks, and materials delivery trucks, on access roads
- Removing vegetation cover
- Constructing roads and well pads
- Drilling production and injection wells
- Constructing fluid sump pits

As successful wells are drilled, geothermal fluids venting to the atmosphere are an additional source of air pollutant emissions. Well venting introduces the potential release of hydrogen sulfide, carbon dioxide, mercury, arsenic, and boron when these compounds are present in the geothermal resource. Hydrogen sulfide is generally the primary pollutant of concern if present in the geothermal resource. The NMED may require a project proponent to establish an air monitoring program for hydrogen sulfide emissions.

Utilization

Constructing a geothermal power plant and its associated infrastructure—roads, pipelines, and transmission lines—during the onset of the utilization phase would create fugitive dust and exhaust from combustion engines. Fugitive dust and exhaust from combustion engines during operations in the utilization phase would be generally limited to worker and maintenance vehicle traffic.

A binary cycle geothermal power plant does not emit air pollutants, except from well venting during maintenance or leaks in the heat exchangers, which could result in the release of volatile organic compounds. The working fluid in a binary power plant may be condensed through air or water cooling. Water cooling produces condensed water vapor plumes. While these plumes do not have a large impact in terms of pollutant emissions, they are a concern in areas of high visual sensitivity, including in the four Class I areas near the project area. Air cooling does not produce steam plumes.

Reclamation and Abandonment

Air quality and AQRV impacts during reclamation and abandonment would be limited to emissions from vehicles, trucks, and construction equipment and to fugitive dust from the movement of vehicles and reclamation of disturbed areas. Depending on the flow and temperature of the geothermal fluids or steam at the well heads at the time of abandonment, well capping could release the range of pollutants listed above under *General Impacts by Geothermal Development Phase—Drilling Operations*.

Emissions by Geothermal Development Phase for the Reasonably Foreseeable Development Scenario

This section describes the air pollutant emissions from each stage of geothermal exploration and development, as described in the RFDS, which also describes the phases as exploration, development drilling and utilization, and final plugging and reclamation. Because the RFDS is the same under all alternatives except Alternative 3, emissions under each of the other alternatives would be the same.

Exploration

Exploration would have temporary impacts on air quality and AQRVs from construction and drilling. Sources of temporary and localized fugitive dust emissions are the following:

- Surface disturbance for temperature gradient wells, slim wells, and exploration roads
- Travel on unpaved roads and surfaces by commute vehicles, delivery trucks, water trucks, and tractor trailers
- Travel on paved roads by commute vehicles, delivery trucks, water trucks, and tractor trailers

Sources of temporary exhaust-related criteria pollutant emissions are the following:

- Gas- and diesel-powered construction equipment for exploration road development
- Drill rigs and auxiliary equipment to develop temperature gradient wells and slim wells
- Tractor trailers to bring in and move out construction and drilling equipment
- Water trucks for dust suppression during road construction and to bring in water for mixing drilling fluids during well development
- Delivery trucks for supplies
- Commute vehicles for road construction and drill rig personnel

Diesel-fired equipment and trucks would also emit small quantities of diesel particulate matter, acetaldehyde, benzene, and formaldehyde.

Temperature gradient wells do not typically come in contact with the geothermal resource; therefore, no release of naturally occurring non-condensable gases, such as carbon dioxide or hydrogen sulfide, or trace amounts of boron, mercury, or arsenic would occur. Slim wells do encounter the geothermal resource and thus have the potential to release these gases; blowout-prevention equipment and monitoring devices for hydrogen sulfide may be required for slim well development and would be determined at the project-level planning stage.

Under the RFDS, the geothermal exploration time frame is one to five years of the 15-year RFDS time frame. **Table 3-8**, below, summarizes the number and type of wells and the area of surface disturbance associated with exploration under the RFDS.

Table 3-8. Summary of Geothermal Exploration Activities and Surface Disturbance

Activity	Amount Expected over 15-Year RFDS Time Frame (2016 to 2031)	Amount of Disturbance (Acres)	Disturbance over Project Area over 15-Year RFDS Time Frame (Acres)
Temperature gradient wells	15 wells	0.25	3.75
Slim wells	5 wells	2.80	14.00
Exploration roads	10 miles of road widened by 8 feet	N/A	9.7
Total			**27.45**

Source: BLM 2015

Table 3-9, below, depicts potential emissions for exploration associated with geothermal exploration drilling, based on the parameters described in **Table 3-8**, above. Emissions are presented to develop a single exploration well and include the following categories:

- Emissions from on-road vehicles and trucks
- Fugitive dust from vehicle travel on unpaved roadways
- Fugitive dust from vehicle travel on paved roadways
- Emissions from drill rigs and auxiliary equipment

Emissions from developing a single well are multiplied by the total number of wells to estimate the total well drilling emissions that would be associated with the RFDS.

In addition to the drilling-related emissions shown in **Table 3-9**, the following construction activities would produce emissions:

- Construction equipment not used for road development
- Fugitive dust during road development

Table 3-9. Geothermal Exploration Well Drilling Emissions

Activity[1]	Carbon Monoxide	Nitrogen Oxides	Volatile Organic Compounds	Sulfur Oxides	PM_{10}	$PM_{2.5}$
On-road vehicle exhaust (tons per well)	0.0281	0.0279	0.0042	0.0001	0.0015	0.0012
Unpaved road dust[2] (tons per well)	-	-	-	-	0.6855	0.0685
Paved road dust (tons per well)	-	-	-	-	0.0260	0.0033
Drill rig and auxiliary equipment (tons per well)	0.1484	0.5419	0.0417	0.0157	0.0339	0.0329
Total (tons per well)	**0.1484**	**0.5419**	**0.0417**	**0.0157**	**0.7469**	**0.1059**
Total[3] (tons per RFDS [20 wells])	**3.53**	**11.40**	**0.92**	**0.32**	**14.94**	**2.12**

Source: Forest Service GIS 2015

[1]Assumptions for equipment use, vehicle miles traveled, and drilling times and durations, along with emission spreadsheet tables, are provided in the Air Quality Technical Report (Forest Service 2016d).

[2]Assumes dust control using watering and speed limits; dust could be further controlled with chemical dust suppressants or by covering roads with aggregate.

[3]Emissions from vehicle travel (on-road exhaust and paved and unpaved road dust) would likely be less under the full RFDS, as drill rig equipment and other construction equipment would likely be moved from well site to well site, resulting in fewer miles traveled than calculated for a single well development.

The primary pollutants of concern relative to construction emissions are fugitive dust from surface disturbance, wind erosion, and travel on unpaved surfaces and criteria pollutant, primarily nitrogen oxide, emissions from the operation of diesel-fired construction equipment, and heavy truck traffic. Because emissions from construction would be temporary and localized and would occur intermittently over one to five years, construction-related emissions from road development have not been quantified for this analysis.

BMPs, such as those identified in Appendix C, would be applied at the permit level to minimize impacts on air quality and AQRVs from construction and surface disturbance. These include measures to mitigate equipment exhaust emissions and measures to control fugitive dust. BMPs would be incorporated into the permit application or may be included in the approved use authorization as conditions of approval.

Development Drilling and Utilization

Development drilling and utilization would have temporary impacts on air quality and AQRVs from construction and drilling. Sources of temporary and localized fugitive dust emissions would be the following:

- Surface disturbance for well pads, transmission lines, pipelines, roads, and power plant construction
- Travel on unpaved roads and surfaces by commute vehicles, delivery trucks, water trucks, and tractor trailers

- Travel on paved surfaces by commute vehicles, delivery trucks, water trucks, and tractor trailers

Sources of temporary exhaust-related criteria pollutant emissions would be the following:

- Gas- and diesel-powered construction equipment for well pad, transmission line, pipeline, road, and power plant construction
- Drill rigs and auxiliary equipment to develop production and injection wells
- Tractor trailers to bring in and move out construction and drilling equipment and materials to construct the power plants
- Water trucks for dust suppression during road construction and to bring in water for mixing drilling fluids during well development
- Delivery trucks for supplies
- Commute vehicles for construction and drill rig personnel

As described above under *Exploration*, diesel-fired equipment and trucks would also emit small quantities of diesel particulate matter, acetaldehyde, benzene, and formaldehyde.

In addition to diesel equipment and vehicle emissions, well drilling has the potential to release non-condensable gases, such as carbon dioxide, hydrogen sulfide, methane, and ammonia, as well as trace amounts of mercury, boron, and arsenic when these compounds are contained in the geothermal resource. The amount and ratio of these constituents varies by geothermal resource, with carbon dioxide generally comprising over 95 percent of the non-condensable gases. Non-condensable gases would be emitted during flow testing, but this would be temporary, lasting until the well is shut in or connected to the pipeline.

While the exact characterization of the geothermal resource that would be developed is not yet known, there is potential for hydrogen sulfide to be present in the resource. Hydrogen sulfide is the non-condensable gas of greatest concern because it can pose a threat to human health at high concentrations (BLM and Forest Service 2008). It also can result in nuisance odor conditions, even at levels below the state standard for hydrogen sulfide. Hydrogen sulfide releases are of greatest concern in the event of a well blowout. Blowout prevention equipment may be required for well development, so large releases of hydrogen sulfide during well development would be unlikely. Some minor releases of hydrogen sulfide could occur during well drilling and flow testing.

The NMED may require that monitoring devices be installed and operated during drilling and testing and that a hydrogen sulfide abatement plan be developed. Any necessary mitigation measures and BMPs would be determined during project-specific NEPA analysis and NMED air permitting at the project-level stage. Such measures as monitoring and abatement would ensure that hydrogen sulfide emissions would not result in unsafe levels and would prevent potential nuisance odors if hydrogen sulfide is present in the geothermal resource.

Under the RFDS, the development drilling and utilization time frame is two to ten years of the 15-year RFDS time frame. **Table 3-10**, below, summarizes the number of wells and the area of surface disturbance associated with development drilling under the RFDS.

Production well development requires much larger drill rigs and auxiliary equipment and longer drilling times than exploration well development. As such, emissions from development drilling

Table 3-10. Summary of Geothermal Development Drilling and Surface Disturbance

Component	Amount Expected over the 15-Year RFDS Time Frame (2016 to 2031)	Amount of Disturbance (Acres)	Disturbance in the Project Area over 15-Year RFDS Time Frame (Acres)
Wells	30 wells	5.0 acres per well	150.00
Transmission lines	Maximum of 14 miles at a width of 200 feet	N/A	339.00
Pipelines	Maximum of 7 miles per power plant with a width of 25 feet	21.2 acres per power plant	106.00
Roads	10 miles of road widened by 2 feet	N/A	2.42
Power plants and ancillary facilities	5 power plants	10.0 acres per power plant	50.00
Total			**647.42**

Source: BLM 2015

operations are much greater than from exploration well operations. For comparison purposes, on a per-well basis, emissions from development drilling operations would not exceed Pre-Construction and New Source Review permit rates of 25 tons per year of criteria pollutants, or PSD construction permit limits for major stationary sources of 250 tons per year of any regulated pollutant. However, production well development associated with a single proposed geothermal power plant (six wells) could exceed the Pre-Construction and New Source Review permit rate. Development of the 30 wells together would not exceed the PSD construction permit limit of 250 tons per year for any regulated pollutant. The RFDS indicates that exhaust emission and dust would be controlled to meet applicable air quality standards for the duration of the drilling operation.

In addition to the development drilling-related emissions shown in **Table 3-11**, the following construction activities would produce air pollutant emissions:

- Non-road construction equipment emissions for well pad, transmission line, pipeline, road, and power plant construction
- On-road vehicle equipment emissions from material and equipment deliveries, water trucks, concrete trucks, and construction personnel commute vehicles
- Fugitive dust emissions from well pad, transmission line, pipeline, road, and power plant development

As described above under *Exploration*, the primary pollutants of concern relative to construction emissions are fugitive dust from surface disturbance, wind erosion, travel on unpaved surfaces, and criteria pollutant emissions, primarily nitrogen oxide, from the operation of diesel-fired construction equipment and heavy truck traffic. Because emissions from construction would be temporary and would occur over two to ten years, construction-related emissions from these activities have not been quantified for this analysis.

Construction for development and utilization would occur at a scale requiring air permits from NMED, as well as implementation of measures to mitigate fugitive dust emissions and equipment exhaust emissions. BMPs, such as those identified in Appendix C, would be applied, as needed, at the BLM permitting level to minimize impacts on air quality from construction and surface disturbance. BMPs would be incorporated into the permit application or may be included in the approved use authorization as conditions of approval.

Table 3-11. Geothermal Development Drilling Emissions

Activity1	Carbon Monoxide	Nitrogen Oxides	Volatile Organic Compounds	Sulfur Oxides	PM10	PM2.5
On-road vehicle exhaust (tons per well)	0.0959	0.0765	0.0139	0.0004	0.0047	0.0036
Unpaved road dust[2] (tons per well)	-	-	-	-	2.96	0.30
Paved road dust (tons per well)	-	-	-	-	0.1091	0.0138
Drill rig and auxiliary equipment[1] (tons per well)	1.85	7.15	0.52	0.15	0.38	0.36
Total (tons per well)	**1.85**	**7.15**	**0.52**	**0.15**	**3.4538**	**0.6774**
Total[3] (tons per 6 wells)	**11.68**	**43.36**	**3.20**	**0.90**	**20.72**	**4.06**
Total (tons per RFDS [30 wells])	**58.38**	**216.80**	**16.02**	**4.51**	**103.61**	**20.32**

Source: Forest Service GIS 2015

[1]Assumptions for equipment use, vehicle miles traveled, and drilling times and durations, along with emission spreadsheet tables, are provided in the Air Quality Technical Report (Forest Service 2016d).

[2]Assumes dust control using watering and speed limits; dust could be further controlled with chemical dust suppressants or by covering roads with aggregate.

[3]Emissions from vehicle travel (on-road exhaust and paved and unpaved road dust) would likely be less under the full RFDS. This is because drill rig equipment and other construction equipment would likely be moved from well site to well site, resulting in fewer miles traveled than calculated for a single well development. In addition, commute-related emissions may be less if on-site worker camps were developed for drill rig personnel.

Under the RFDS, five 25-MW geothermal binary cycle power plants would operate for 30 to 50 years. Operating a binary cycle geothermal power plant does not emit air pollutants, except from well venting during maintenance or from leaks in the heat exchangers, which could result in the release of volatile organic compounds.

Binary cycle power plants operate on water at temperatures of approximately 225ºF to 360ºF. Binary cycle plants use the heat from the hot water to boil a working fluid, usually an organic compound with a low boiling point. The working fluid is vaporized in a heat exchanger and is used to turn a turbine. The water is then injected back into the ground to be reheated. Under normal operations, binary power plants operate in a closed environment, where the geothermal fluid and the working fluid do not contact the atmosphere. The working fluid is a substance with a low boiling point, typically a butane or pentane hydrocarbon.

Because the power plant would be a closed system with the working fluid rarely exposed to the atmosphere, little impact on air quality is expected from the operation of the power plant. During maintenance or if there are leaks in the system, there may be emissions of nitrogen, carbon dioxide, and oxygen from the working fluid. Mitigation measures, such as those identified in Appendix C, may be applied at the permit level to monitor for emissions from plant operations.

In addition, the RFDS indicates that because of the cool air temperatures and the scarcity of water in the project area, the binary plants would likely be air cooled instead of water cooled. Air-cooled plants do not produce steam plumes; therefore, plant operations would not affect visibility in any of the four Class I areas within 62 miles of the project area. Operation of a binary power plant would likely have emissions below the level that constitutes a major source of new emissions in the federal PSD program.

The RFDS estimates that each plant would employ 9 shift workers and up to 12 additional workers per day. Emissions would be limited primarily to vehicle and maintenance equipment, including vehicle commute traffic, delivery traffic, and on-site maintenance truck and equipment use. These emissions would be low.

Reclamation and Abandonment

Air quality and AQRV impacts during reclamation and abandonment would include emissions from vehicles, construction equipment, and truck traffic, from dismantling the power plant and other unnecessary infrastructure, and fugitive dust from the movement of vehicles and reclamation of disturbed areas. Depending on the flow and temperature of the geothermal fluids or steam at the well heads at the time of abandonment, well capping could result in the potential release of the range of pollutants listed above under *Development Drilling and Utilization*. Because reclamation and abandonment would occur 30 to 50 years in the future, no emissions have been calculated for this action. However, these activities would be subject to NEPA analysis and BLM permitting, at which time mitigation measures and BMPs would be determined to minimize or mitigate impacts on air quality.

3.10.2.4 Impacts Under Alternative 1

Alternative 1 would have the same impacts on air quality as described under Emissions by Geothermal Development Phase for the RFDS, above. Well drilling emissions, as quantified in **Table 3-9** and **Table 3-11**, would emit criteria air pollutants, hazardous air pollutants, and GHGs in the project area. Exploration drilling emissions for all 20 wells would be far below the PSD permitting threshold of 250 tons per year (presented for comparison purposes only). These emissions would also be less than 1 percent of county emission levels described in **Table 3-7** for all criteria pollutants.

Development drilling would produce a greater level of emissions. Emissions to develop and complete all 30 wells would still be below the PSD permitting threshold of 250 tons per year. These emissions would also be less than 1 percent of county emission levels described in **Table 3-7** for volatile organic compounds, carbon monoxide, PM_{10}, and $PM_{2.5}$ (when fugitive dust is included), 1.35 percent of county emissions for nitrogen oxides, and 4.05 percent of county emissions for sulfur dioxide. Thus, development drilling would contribute to county emissions but not to a substantial degree, relative to overall emissions. Drilling emissions would be a temporary and short-term source of emissions.

Construction activities would emit similar pollutants, as described for drilling. However, they would be at lower levels for exploration and at similar or lower levels for development and utilization, given the amount of surface disturbance described in **Table 3-10** and the diesel-fired heavy construction equipment that would be necessary to construct the power plants and associated infrastructure. As described under *Emissions by Geothermal Development Phase for the Reasonably Foreseeable Development Scenario*, construction would be temporary and would occur over a one- to five-year exploration time frame and a two- to ten-year development time frame.

Both drilling and construction emissions would be minimized or mitigated through BMPs applied at the permit level to minimize impacts on air quality from well drilling, facility and infrastructure construction, and surface disturbance. BMPs would be incorporated into the permit applications or may be included in the approved use authorizations as conditions of approval. BMPs identified in Appendix C include measures to mitigate equipment exhaust emissions and control fugitive dust. State air permitting would impose additional limits on allowable emissions from future development activities. The permits required and the conditions imposed in these permits would be determined during project-specific permitting processes.

Long-term emissions from operating the binary cycle geothermal power plants would be low. Binary cycle power plants are closed-loop systems and generally do not emit pollutants under normal operating conditions. Because the plants would be air cooled, they would not emit steam plumes and, therefore, would not affect visibility in the four Class I areas within 62 miles of the project area. They also would not emit hydrogen sulfide; therefore, plant operations would not cause nuisance odor conditions.

3.10.2.5 Impacts Under Alternative 2

The RFDS under Alternative 2 would be the same as described under Alternative 1; therefore, impacts related to the overall levels of emissions would be the same. Impacts on AQRVs would also be the same.

While the moderate to major constraints in areas open to geothermal leasing would not affect the overall level of emissions that would result from geothermal development in the project area, it may alter the locations where geothermal development would occur. More areas would be constrained under Alternative 2 than under Alternative 1; therefore, geothermal exploration and development under Alternative 2 could occur in a smaller area in the project area than under Alternative 1. As the RFDS indicates that geothermal plants would be spaced by one mile or more, the overall direct and indirect impacts would be the same as described under Alternative 1.

3.10.2.6 Impacts Under Alternative 3

Under Alternative 3, there would be no geothermal development; therefore, no direct or indirect impacts on air quality or AQRVs would occur.

3.10.2.7 Impacts Under Alternative 4

Direct and indirect impacts on air quality and AQRVs under Alternative 4 would be the same as described for Alternative 1.

3.10.2.8 Cumulative Impacts

Cumulative air quality impacts occur when multiple projects affect the same geographic area at the same time, or when sequential projects extend the duration of air quality impacts on a given area over a longer period. Air quality monitoring data trends can predict future air quality conditions in the cumulative impacts area. Past and present actions in the project area have affected air quality such that monitored levels of ozone are nearing the NAAQS. Ozone levels generally are attributed to oil and gas operations and power plants, including the San Juan Generating Station and the Four Corners Power Plant, in the region (Four Corners Air Quality Task Force 2007).

Past and present actions on SFNF lands that have affected air quality are those related to development, including timber harvest, road development, and mineral development. Reasonably foreseeable actions would also affect air quality, including pumice mine expansion and development and actions related to vegetation management. These actions would have temporary and intermittent air quality impacts from vehicle and equipment use and surface disturbance.

The contribution of Alternatives 1, 2, and 4 to cumulative air pollutant emissions would be minor, and such impacts would be minimized by implementing BMPs identified in Appendix C. Air quality impacts from these alternatives would consist of temporary impacts during well exploration and development. As a result, the potential for cumulative impacts from this alternative would be short term and minimal, as binary cycle power plants are closed-loop systems and do not emit pollutants under normal operating conditions. Alternative 3 would not emit air pollutants; therefore, there would be no cumulative impacts associated with this alternative.

3.11 Vegetation

3.11.1 Affected Environment

There are twelve major vegetation communities in the 194,900-acre project area (**Table 3-12**, Major Vegetation Communities in the Project Area, and Figure 2 in the SFNF Geothermal Leasing EIS, Wildlife, Fisheries, and Plants Report [Forest Service 2016e]).

Table 3-12. Major Vegetation Communities in the Project Area

Vegetation Community	Acres	Percent of Project Area
Blue grama grassland	3,200	1.6
Perennial grass mix	7,400	3.8
Big sagebrush	4,100	2.1
Deciduous shrub mix	5,500	2.8
Aspen	4,900	2.5
Juniper	11,100	5.7
Pinyon/pinyon-juniper	20,800	10.7
Ponderosa pine	65,200	33.4
Spruce and fir	9,600	4.9
Upper deciduous evergreen mix	63,200	32.4
Sparsely vegetated	Less than 100	0.0
Total	**194,900**	**100.00**

Source: Forest Service GIS 2015

The dominant vegetation communities are ponderosa pine (*Pinus ponderosa*), upper deciduous evergreen mix, and pinyon-juniper. The ponderosa pine forest vegetation community is dominated by ponderosa pine but includes other species, such as oak (*Quercus* spp.), juniper (*Juniperus* spp.), and pinyon (*Pinus edulis*). Such species as aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and blue spruce (*Picea pungens*) may also be present but occur infrequently as small groups or individual trees. This forest vegetation community typically occurs with an understory of grasses and forbs and sometimes includes shrubs. There are 65,200 acres of ponderosa pine forest, covering approximately 33 percent of the project area.

Suitable mature ponderosa pine habitat is abundant in the project area; however, much of this forest type has become crowded and overstocked with relatively young trees. Open areas are gradually filling in with trees. These systems have moved from open forests, dominated by groups and clumps of trees of different ages and sizes, to a dense, continuous blanket of evenaged (80- to 90-year-old), pole-sized (5- to 12-inch-diameter) trees. Tree densities in the southwest Jemez Mountains have increased 10-fold, from an average of 15 to 56 trees per acre to 500 trees per acre (Forest Service 2010). There are fewer large (over 18-inch-diameter) trees, old growth trees, snags, and down wood.

Openings and understory plants are scarce. The common, open park-like characteristic of reference conditions for ponderosa pine forests (Swetnam and Baisan 1996) promoted greater faunal diversity and were better adapted to fire than the dense stands of today. Ponderosa pine forests in the project area are generally denser and more continuous than in pre-settlement reference conditions, and accumulations of forest litter and woody debris are much higher than would have occurred under the historic disturbance regime. The dense tree canopy also inhibits the growth of understory grasses, forbs, and shrubs. Instead, there is a carpet of pine needles.

The lack of fire disturbance has led to fuel loads that increase the risk of uncharacteristically severe wildfire and drought-related mortality. This means there is more competition for light, water, and nutrients. On average, the trees are now smaller and grow more slowly. There is a moderate risk of insect and disease outbreak, which is also a function of increased tree density.

The spruce/fir community occurs in high elevation areas in the project area. This community is dominated by blue spruce, Douglas-fir, and white fir. Mature and old growth spruce/fir forests on the SFNF provide valuable habitat for various special status wildlife species. There are 9,600 acres of spruce/fir, covering approximately 5 percent of the project area.

Upper deciduous evergreen mix is present throughout the project area between the ponderosa pine and the spruce/fir vegetation communities. This community contains a mix of ponderosa pine, blue spruce, Douglas-fir, white fir, and aspen. The canopy cover for this community is composed of less than 75 percent deciduous trees (Brohman and Bryant 2005). There are 63,200 acres of upper deciduous evergreen mix, covering approximately 32 percent of the project area.

Aspen-dominated stands are currently a minor part of New Mexico forests and forests in the project area, though they are considered important for providing diversity of wildlife habitat, forage, and watershed values in the conifer-dominated forests. There are approximately 4,900 acres of aspen covering approximately 3 percent of the project area. Aspen forests are unusual because they reproduce primarily by suckering from the parent root system. Often a disturbance or dieback is necessary to stimulate stand regeneration.

The pinyon/pinyon-juniper cover type is collectively composed of the pinyon woodland, pinyon-juniper grassland, pinyon-juniper sagebrush, pinyon-juniper evergreen shrub, and pinyon-juniper persistent woodland communities. Two-needle pinyon pine (*Pinus edulis*) is common, as is one-seed (*Juniperus monosperma*), Utah (*J. osteosperma*), Rocky Mountain (*J. scopulorum*), and alligator (*J. deppeana*) juniper. Species composition and stand structure vary by location, primarily due to precipitation, elevation, temperature, and soil type. There are 20,800 acres of pinyon-juniper habitat, comprising approximately 11 percent of the project area.

Most of the pinyon-juniper vegetation communities are younger and denser than they were historically because of changes in wildfire occurrence and past livestock and wildlife grazing. Greater tree density has increased competition for water and nutrients. This, in turn, has caused a reduction in understory plant cover and diversity, a loss of ground cover, and subsequent increases in soil erosion. Pinyon-juniper woodland supports a wider array of birds and mammals than ponderosa pine forest. Several species of birds are directly associated with pinyon-juniper habitats, including pinyon jays (*Gymnorhinus cyanocephalus*) and juniper titmice (*Baeolophus* *ridgwayi*). Woodlands provide key winter habitat for a range of species, including ungulates and raptors.

The pinyon-juniper communities produce hard mast that supports high densities of small mammals, making these areas important for foraging carnivorous species, including black bear (*Ursus americanus*), birds, and snakes. Many wildlife species select large trees for foraging and large snags for nesting. Current conditions slow the growth rates of trees, prolonging the time required to develop old and large trees. Slowed growth rates can also leave large and old trees more vulnerable to short- and long-term weather and climate trends (Kane and Kolb 2014). The delay in replacing this component of woodland habitat also delays future large-diameter snag recruitment.

Riparian areas occupy a small percent of the landscape of the project area; however, their importance far outweighs their representation on the landscape. Riparian areas provide valuable habitat for fish, wildlife, migratory birds, and special status species. Riparian areas are found as narrow bands of shrubs or trees lining stream banks, seeps, and springs. Often riparian areas are composed of a mosaic of multiple communities and are found throughout the project area. Riparian habitat in the project area occurs along the Jemez River, Redondo Creek, San Antonio Creek, Rio Cebolla, Coyote Creek, and other perennial and intermittent streams, seeps, and springs. Common species include alder (*Alnus* spp.), willow (*Salix* spp.), aspen, maple (*Acer* spp.), dogwood (*Cornus* spp.), cottonwood (*Populus* spp.), and ash (*Fraxinus* spp.; Dreesen et al. 2002).

Nonnative and invasive plants (also known as noxious weeds) are aggressive and displace native plant species. The National Invasive Species Council defines invasive species as “those (species) that are not native to the ecosystem under consideration and that cause or are likely to cause economic or environmental harm or harm to human, animal, or plant health.” Noxious and invasive weeds that have the potential to occur in the project area are bull thistle (*Cirsium vulgare*), Canada thistle (*C. canadensis*), field bindweed (*Convolvulus arvensis*), nodding thistle (*Carduus nutans*), poison hemlock (*Conium maculatum*), cheatgrass (*Bromus tectorum*), oxeye daisy (*Leucanthemum vulgare*), spotted knapweed (*Centaurea stoebe*), dalmation toadflax (*Linaria dalmatica*), Russian olive (*Elaeagnus angustifolia*), saltcedar (*Tamarix* spp.), Siberian elm (*Ulmus pumila*), hoary cress (*Cardaria draba*), scotch thistle (*Onopordum acanthium*), and Russian knapweed (*Rhaponticum repens*; Forest Service 2013).

The natural fire regime has been interrupted since the late 1800s. High numbers of sheep and cattle that grazed in the Jemez Mountains reduced the native grasses that carried surface fires. The Forest Service suppressed wildfires, even those that would have benefited the landscape. Without fire to control their numbers, seedlings and saplings thrived. As a result, the forests in the project area are dominated by dense thickets of pole-sized trees (5 to 16 inches in diameter). Understory plants and grasses, large, thick-barked pine trees, and old growth are lacking. The species composition has shifted, and ponderosa pine forests now resemble mixed conifer forests with more Douglas-fir, white fir, and limber pine (Forest Service 2015b).

3.11.2 Environmental Consequences

3.11.2.1 Scoping Comments on Resource

The following issues specific to vegetation were identified during the public scoping period:

- How would vegetation loss from geothermal leasing affect soil erosion?

- How would noxious and invasive weeds be managed in geothermal leasing areas?

3.11.2.2 How Resource Impacts Were Evaluated

Method

Leasing geothermal resources would not affect vegetation or important habitats and communities. These resources would be affected only by development of specific geothermal projects that occurred after the leasing action. Potential impacts of geothermal development were evaluated based on the typical disturbance of geothermal projects for the various stages of development and then were assessed based on projected intensity, as described in the RFDS (BLM 2015). The types of vegetation and important habitats and communities that could be affected by geothermal development depend on the specific location of the proposed projects, which are unknown at this time. In general, the vegetation communities described in **Section 3.11** could be affected by geothermal development, as described below.

Indicators

Potential impacts on vegetation could occur if anticipated future actions, consistent with implementing the alternatives described in **Chapter 2**, were to result in the following:

- Affect a plant species, habitat, or natural community recognized for ecological, scientific, recreational, or commercial importance
- Affect a species, habitat, or natural community that is specifically recognized as biologically significant in local, state, or federal policies, statutes, or regulations
- Establish or increase noxious weed populations
- Destroy or extensively alter habitats or vegetation communities in such a way that would render them unfavorable to native species
- Conflict with Forest Service management strategies

Assumptions

This analysis assumes the following:

- NSO stipulations would generally prevent direct disturbance to vegetation by restricting surface-disturbing activities where they are applied, except when exceptions, waivers, or modifications are met.
- CSU stipulations could be used to avoid impacts on sensitive vegetation in certain areas.
- The degree of impact attributed to any one disturbance or series of disturbances would be influenced by several factors, including location in the watershed; the type, time, and degree of disturbance; existing vegetation; the amount, type, and timing of precipitation; and mitigating actions applied to the disturbance.
- The Forest Service would comply with its own weed control plans.

3.11.2.3 Common Impacts Associated with Geothermal Development

Common impacts on vegetation associated with geothermal development are described in the 2008 Geothermal PEIS (BLM and Forest Service 2008) and are incorporated into this document by reference.

Regardless of the location of geothermal development projects, the nature of impacts from exploration and development on vegetation would be similar in all vegetation communities.

Vegetation would be affected by direct destruction and removal, erosion, and fugitive dust. In addition, potential direct and indirect impacts could occur from exposure to such contaminants as oil and fuel leaks from heavy equipment, accidental fire caused by on-site workers or heavy equipment, and the introduction of invasive species. However, BMPs identified in Appendix C would minimize these risks.

The extent of the impacts is typically associated with the size of the area that is disturbed and the types of vegetation habitats and communities present. In general, localized impacts from geothermal development on the scale anticipated by the RFDS on vegetation communities that are common in the project area, such as ponderosa pine and upper deciduous evergreen mix forests, would be unlikely to change the composition or health of most vegetation communities.

3.11.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. Vegetation communities may be impacted by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres may be disturbed in vegetation communities in the project area. The Forest Service has determined that the JNRA (approximately 28,900 acres) is excluded from geothermal leasing on the basis of existing laws, regulations (43 CFR, Subpart 3201.11), and executive orders. There would be no direct disturbance to vegetation within the JNRA under Alternative 1.

3.11.2.5 Impacts Under Alternative 2

Under Alternative 2 approximately 32,000 acres would be closed to geothermal leasing, while approximately 136,650 acres of the NFS lands in the project area would be allocated as open to geothermal leasing, subject to existing laws, regulations, formal orders, and stipulations. Vegetation communities may be impacted by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres of disturbance may occur in vegetation communities in the project area; however, the location of disturbance is unknown. Vegetation at drilling pads, facilities, roadways, and transmission corridors may be affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development. Impacts on wetland and riparian areas would be minimized by the leasing stipulations described in **Chapter 2**.

Fragmentation can facilitate the spread and introduction of invasive plant species. Roads and other corridors can facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wild or human vectors (Trombulak and Frissell 2000). Sensitive plants can be affected by invasive vegetation through competition for resources and available habitat. BMPs for noxious weeds include measures such as weed monitoring, education of personnel on weed identification, use of certified weed-free mulch, a controlled inspection and cleaning area for vehicles arriving from locations with known weed infestations, and developing a plan for control of noxious weeds and invasive species.

Geothermal development under Alternative 2 could increase the risk of wildland fire in the project area. Equipment operations, increased vehicular and human traffic, use of drilling muds, and extraction of geothermal fluids can increase the risk of fires. Vehicles, electrical lines, and smoking can all result in accidental fires. High severity wildfires destroy vegetation and seed banks for native plants. In addition, fire can result in indirect impacts, such as helping establish and spread invasive species by increasing plant resource availability, reducing competition, or altering sediment transport of an affected watershed (USGS 2002; Brooks and Lusk 2008). Low severity wildfires are important ecologically and help maintain variable tree densities. BMPs would be followed, and operators would develop a fire management strategy to implement measures to minimize the potential for a human-caused fire.

3.11.2.6 Impacts Under Alternative 3

There would be no lands available for leasing in the project area under Alternative 3; there would be no direct or indirect impacts on vegetation from geothermal activities.

3.11.2.7 Impacts Under Alternative 4

Under Alternative 4 approximately 28,900 acres would be closed to geothermal leasing, while approximately 139,800 acres of the NFS lands in the project area would be allocated as open to geothermal leasing, subject to existing laws, regulations, formal orders, and stipulations. Direct and indirect impacts on vegetation would be similar to those under Alternative 2. However, the intensity of disturbance could be more severe and certain areas may be more likely to be disturbed (specifically intermittent streams and viewsheds with a Scenery Management System integrity level of very high). Therefore, impacts on vegetation communities in these areas (direct vegetation removal, or indirect spread and establishment of noxious weeds) would be more likely.

3.11.2.8 Cumulative Impacts

The cumulative impacts analysis region of influence for vegetation is the three level 4 watersheds that intersect the project area: the Rio Grande-Santa Fe, Rio Chama, and Jemez watersheds. Past, present, and reasonably foreseeable future actions within these watersheds are the Pueblo of Jemez Red Rocks Dam Repair, the Abiquiu Land Grant Waterline Replacement, and the McKinney County Dam; mineral development in the South Pit Pumice Mine Expansion and the Duran 2010 Pumice Mine; and habitat improvement projects, such as the Southwest Jemez Mountains Restoration Project, the Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project, the Pueblo of Jemez Owl Springs Bridge Sediment Removal Project, the New Mexico Meadow Jumping Mouse Critical Habitat Protection Project, and the Supplement to the Final EIS for Invasive Plant Control Project.

Implementation of Alternatives 1, 2, or 4 would increase the number of acres of disturbance in the region of influence (i.e., the three level 4 watersheds) over the long term, when combined with other surface-disturbing projects. However, under Alternatives 2 and 4, NSO and CSU stipulations would mitigate impacts on vegetation by restricting where development could occur. Habitat improvement projects could help to restore vegetation conditions within the cumulative impacts analysis area to a more fire-adapted ecosystem.

As a result of exploration, drilling, and utilization disturbance, there is the potential for nonnative and invasive species to colonize and dominate sites. The facilitation of seed dispersal could result from construction equipment transporting invasive species from the construction areas to adjacent lands along access roads and main roads. However, BMPs identified in Appendix C (such as weed monitoring, education of personnel on weed identification, use of certified weed-free mulch, a controlled inspection and cleaning area for vehicles arriving from locations with known weed infestations, and weed control plans) and other weed control efforts on the Coyote, Cuba, Espanola, and Jemez Ranger Districts would reduce this risk. This impact could occur under Alternatives 1, 2, and 4.

Geothermal development within the project area could increase the risk of wildland fire in the project area, which could spread to adjacent land such as the Valles Caldera. Wildfires that spread beyond the project area could further impact vegetation communities affected by recent fires, such as the Thompson Ridge fire (2013), Las Conchas fire (2011), Tres Lagunas fire (2013), and South Fork fire (2010). The Las Conchas and Thompson Ridge fires in particular burned much of the upper deciduous evergreen mix forest type on the Valles Caldera. Disturbance in this vegetation type could further alter or remove upper deciduous evergreen mix forest communities. However, of the 60,600 acres of upper deciduous-evergreen mix forest type in the decision area, the majority would be closed to geothermal leasing or NSO under Alternatives 2 and 4. Under Alternative 2, 400 acres would be open subject to standard lease terms and conditions, while 1,500 acres would be open subject to standard lease terms and conditions under Alternative 4 (Forest Service GIS 2015). BMPs would minimize the potential for a human-caused fire.

Combined with other reasonably foreseeable future actions, no significant cumulative impacts on vegetation are expected from Alternatives 1, 2, and 4. Alternative 3 would have no cumulative impacts on vegetation.

3.12 Fish and Wildlife

3.12.1 Affected Environment

This section discusses management indicator species (MIS) and migratory birds. The detailed description and analysis of MIS in the SFNF Geothermal Leasing EIS Fish, Wildlife, and Plant Report (Forest Service 2016e) is incorporated by reference and summarized here. In this analysis, these species are used as a proxy for all fish and wildlife in the project area. MIS are identified as representing a group of species having similar habitat requirements. MIS in the SFNF are shown below in **Table 3-13**.

3.12.1.1 Rocky Mountain Bighorn Sheep

Bighorn sheep serve as a management indicator for alpine meadow habitat. On the SFNF, Rocky Mountain bighorn sheep inhabit the highest alpine areas of the Sangre de Cristo Mountains in the Pecos Wilderness, outside the project area. Bighorn sheep were reintroduced into the Cochiti Canyon, approximately 10 miles southeast of the project area, and may use the project area as transition habitat. Habitat conditions in the Pecos Wilderness are generally fair to good, but the limiting factor is severe winter conditions, where quality and quantity of forage can fluctuate significantly. The habitat trend for bighorn sheep on the SFNF is stable.

Species Status and Population Trend

In 2011 the number of bighorn sheep in the SFNF was 110 to 125 adults. The Rocky Mountain Bighorn Sheep population ranks as uncommon for the SFNF. This means that the estimated number of breeding females ranges between 100 and 1,000 individuals. The population trend for Rocky Mountain bighorn sheep is declining on the SFNF. There is no suitable or occupied habitat for bighorn sheep within the project area.

Table 3-13. Southwestern Region Regional Forester's MIS on the SFNF

Common Name	Species	Species Status[1]	Species or Habitat in the Project Area	Habitat Association	Acres in the Project Area	Acres in SFNF
Rocky Mountain bighorn sheep	*Ovis canadensis canadensis*	MIS	No	Alpine meadow	0	7,900
Rocky Mountain elk	*Cervus elaphus*	MIS	Yes	Mid-elevation grasslands (generally less than 9,000 feet), meadows and forest	157,800	1,424,900
Merriam's turkey	*Meleagris gallopavo merriami*	MIS	Yes	Mature ponderosa pine forest	59,400	633,700
Mourning dove	*Zenaida macroura*	MIS	Yes	Mid- and low-elevation grasslands, woodlands, and ponderosa pine	48,900	647,300
Hairy woodpecker	*Pica villosa*	MIS	Yes	Mature forest and woodland	10,200	84,100
Pinyon jay	*Gymnorhinus cyanocephalus*	MIS	Yes	Pinyon-juniper woodlands	12,600	250,100
Mexican spotted owl (MSO)	*Strix occidentalis lucida*	T/MIS	Yes	Late-seral stage mixed-conifer	72,500	667,600
Rio Grande cutthroat trout (RGCT)	*Oncorhynchus clarki virginalis*	SS/MIS	Yes	Riparian and stream habitat; good water quality	23 miles	135 miles
Migratory birds	—	—	Yes	All	194,900	1,558,500

Source: Forest Service GIS 2015, Forest Service 1987
[1]T = Threatened under the Endangered Species Act of 1973 (ESA)
SS = Forest Service Region 3 Forester's sensitive species
MIS = Forest Service Region 3 Forester's MIS
[2]D = Documented, reliable, recorded observation in appropriate habitat within the SFNF boundary

3.12.1.2 Rocky Mountain Elk

Rocky Mountain elk are primarily grazers and inhabit most forest types with good forage and cover. However, they were selected to represent mid-elevation grasslands (generally less than 9,000 feet), meadows, and forested areas, which are present in the project area (Amy and Cook 2012). Overall, elk habitat is rated as stable.

Species Status and Population Trend

The total number of elk on the SFNF is estimated at between 7,500 and 11,000 (Amy and Cook 2012). The Rocky Mountain elk population ranks as common for the SFNF. This means that the estimated number of breeding females ranges between 1,000 and 10,000. The population may fluctuate from year to year based on hunting pressure and a variety of environmental factors. The population trend for the Rocky Mountain elk is ranked as increasing on the SFNF. The objective, however, is to maintain the herd at about its current level. In recent years, the NMDGF has increased the number of elk hunting licenses, including late-season cow permits, in an attempt to maintain current elk populations.

3.12.1.3 Merriam's Turkey

Merriam's turkeys use a wide range of vegetation communities, but they were selected to serve as a management indicator of healthy, mature ponderosa pine habitat, which is present in the project area (Amy and Cook 2012). The estimated habitat trend for turkey is relatively stable, based on disturbed acres providing additional feeding habitat and undisturbed areas declining in quality due to forest-encroachment issues.

Species Status and Population Trend

Merriam's turkey has the widest distribution and is known to reside on all the ranger districts on the SFNF. They are ranked as common on the SFNF, which means that the estimated number of breeding female birds ranges between 1,000 and 10,000. The NMDGF estimates between 35,000 and 40,000 wild turkeys throughout the state. The population trend for Merriam's turkey on the SFNF is rated as stable. This estimate is based on the amount of habitat available, breeding bird surveys, and professional opinion of local biologists. Statewide, population numbers are expected to increase. The NMDGF has not conducted hunter success surveys over the past few years and currently does not conduct population surveys for Merriam's turkey (Amy and Cook 2012).

3.12.1.4 Mourning Dove

Mourning dove serves as a management indicator of healthy mid- and low-elevation grasslands, woodlands, and ponderosa pine habitats, which are present in the project area (Amy and Cook 2012). The habitat trend for the mourning dove is stable to increasing across the SFNF. Emphasis in healthy forest restoration should result in an upward trend.

Species Status and Population Trend

Mourning doves are common throughout the state. They are ranked as common on the SFNF, meaning that the estimated number of breeding pairs ranges between 1,000 and 10,000. The mourning dove is listed as secure in New Mexico (NatureServe 2011a). The population trend for the mourning dove on the SFNF is stable, based on the statewide trend and breeding bird surveys on and next to the SFNF.

3.12.1.5 Hairy Woodpecker

Hairy woodpeckers serve as a management indicator for mature forest and woodland habitats—ponderosa pine, mixed-conifer, spruce/fir, aspen, and oak woodland—which are present in the project area (Amy and Cook 2012). The SFNF supports adequate numbers of snags and downed logs for hairy woodpecker habitat.

Species Status and Population Trend

This species is widespread across the SFNF and can be found in any of the suitable habitat types. The hairy woodpecker population is ranked as abundant on the SFNF. This means that the estimated number of breeding pairs ranges between 10,000 and 100,000. Breeding bird survey routes on or near the SFNF reported to the USGS between 1987 and 2010 indicate a stable to increasing trend for hairy woodpecker on the SFNF. The hairy woodpecker is listed as secure in New Mexico (NatureServe 2011b). The population trend for the hairy woodpecker on the SFNF is stable, based on the statewide trend and breeding bird surveys in and next to the SFNF.

3.12.1.6 Rio Grande Cutthroat Trout

RGCT serve as a management indicator of healthy riparian and stream habitat and good water quality. Since development of the Forest Plan (Forest Service 1987), stream habitat conditions for RGCT have varied from slightly declining to slightly improving. However, large catastrophic wildfires (e.g., Thompson Ridge fire [2013], Tres Laguna fire [2013], Las Conchas fire [2011], and South Fork fire [2010]) have severely impacted important RGCT streams in the SFNF, causing the habitat quality to decline.

Species Status and Population Trend

RGCT is also a Forest Service Region 3 sensitive species and was a candidate for federal protection under the ESA, from 2008 to 2014; then it was removed from candidacy when it was determined that listing was not warranted (79 *Federal Register* 59140-59150, October 1, 2014; NMDGF 2014). The SFNF manages approximately 1,072 miles of perennial streams. Approximately 965 miles were thought to be historically occupied before nonnative trout were stocked, and all are considered potential habitat in the State-Wide Conservation Agreement. RGCT currently live on 135 miles of perennial streams in the SFNF (NMDGF 2014). The population trend for RGCT on the SFNF is stable to declining.

3.12.1.7 Pinyon Jay

Pinyon jays can be found in a wide variety of vegetation communities, but they were selected to serve as a management indicator of healthy pinyon-juniper habitat. Their greatest threat is the continued loss of cone-producing pinyon due to drought and insect infestation. Because of this wide-scale loss of pinyon, the habitat trend for pinyon jay is ranked as declining on the SFNF.

Species Status and Population Trend

Survey results for routes on or near the SFNF reported to the USGS, between 1987 and 2010, indicate a stable population trend for pinyon jay on the SFNF, although the USGS data indicate a downward trend throughout New Mexico and the West (Amy and Cook 2012). NatureServe (2011c) lists the pinyon jay as vulnerable in New Mexico.

3.12.1.8 Mexican Spotted Owl

Mexican spotted owl (MSO) serves as a management indicator for late seral stage mixed-conifer habitat. MSO are discussed in detail in **Section 3.13**, Threatened and Endangered Species and Special Status Species.

3.12.1.9 Migratory Birds

The Migratory Bird Treaty Act of 1918 (MBTA) implements a series of international treaties that provide for migratory bird protection. Under the MBTA, it is unlawful, except as permitted by regulations, “to pursue, take, or kill any migratory bird, or any part, nest or egg of any such bird” (16 USC, Section 703); however, the MBTA does not regulate habitat. The list of species protected by the MBTA was revised in March 2010 and includes almost all 1,007 bird species that are native to the United States. The Forest Service Southwestern Region currently analyzes the following impacts on migratory birds:

- Impacts on highest priority species listed by New Mexico Avian Conservation Partners
- Impacts on United States Fish and Wildlife Service (USFWS) priority species in the Southern Rockies/Colorado Plateau bird conservation region
- Impacts on Important Bird Areas
- Impacts on important overwintering areas

Highest Priority Species Listed by New Mexico Avian Conservation Partners

New Mexico Avian Conservation Partners considers eight risk factors in identifying conservation priority species: global abundance, New Mexico breeding abundance, global breeding distribution, New Mexico breeding distribution, threats to breeding in New Mexico, importance of New Mexico to breeding, global winter distribution, and threats on wintering grounds. Species with the highest risk factors are classified as “highest priority” for conservation action. This evaluation addresses general impacts on migratory birds and impacts on highest priority species for the main habitat types found in the project area (New Mexico Partners in Flight 2013).

New Mexico Partners in Flight Bird Conservation Plan (New Mexico Partners in Flight 2013) lists priority species of concern by vegetation type. All highest priority species were reviewed for vegetation types found in the project area for spruce/fir, mixed-conifer, ponderosa pine, pinyon-juniper, montane riparian, wet meadows/montane grasslands, middle-elevation riparian, and cliffs and caves (New Mexico Partners in Flight 2013). These include aspen, juniper, pinyon, pinyon-juniper, ponderosa pine mix, spruce/fir, and upper deciduous evergreen forest.

USFWS Priority Species in the Southern Rockies/Colorado Plateau Bird Conservation Region

The following criteria are used to select species for consideration and inclusion on bird conservation region lists:

- Begin with a list from appropriate bird conservation initiative
- Follow criteria for appropriate bird groups
- Add nonbreeding species, if they occur at significant relative density scores or have moderate or high threat levels in nonbreeding season, if not already included due to breeding population
- Consider subspecies and populations, where appropriate, and where information on their status is available
- Remove sport-hunted species and federally listed threatened or endangered populations (retaining non-listed populations with notation)
- Add recently ESA de-listed, candidate, or proposed species not already included
- In very limited circumstances, add or remove species and document the rationale when USFWS expertise, supplemental information, or local data indicate a much greater or lesser degree of concern than that reflected by bird conservation initiative scoring

There are 27 species of birds on the list for the Southern Rockies/Colorado Plateau bird conservation region.

Important Bird Areas

There are no designated Important Bird Areas in the project area; however, the 89,000-acre Valles Caldera/Jemez Mountains Important Bird Area is next to the project area.

Overwintering Areas

Many important overwintering areas are large wetlands. Important overwintering areas recognized on the SFNF are Rio Chama, Rio Grande corridor, and Pecos Canyon. The project area is not recognized as an important overwintering area, because significant concentrations of birds do not occur there, nor do a unique or a high diversity of birds winter there.

3.12.2 Environmental Consequences

3.12.2.1 Scoping Comments on Resource

The following issue specific to fish and wildlife was identified during the public scoping period:

- What are the short- and long-term impacts of geothermal leasing on cold-water fisheries, wildlife corridors, critical wildlife habitat areas, fish hatcheries, and other important or sensitive fish and wildlife habitat in the project area?

3.12.2.2 How Resource Impacts Were Evaluated

Method

Leasing geothermal resources does not affect fish and wildlife. These resources would be affected only by subsequent development of specific geothermal projects. Potential impacts of geothermal development were evaluated based on the typical disturbance of geothermal projects for the various stages of development and then assessed based on projected intensity, as described in the RFDS. The types of fish and wildlife that could be affected by geothermal development depend on the specific location of the proposed project, the time of year, the project design, and its environmental setting. The analysis uses Forest Service MIS as a proxy for general impacts on non-sensitive fish and wildlife. Impacts on federally listed Forest Service sensitive species are discussed in **Section 3.13**. Since most fish and wildlife species rely to some extent on the vegetation in the project area, impacts on vegetation, as described in **Section 3.11**, would also likely impact fish and wildlife habitat.

Indicators

Indicators of impacts on fish and wildlife are as follows:

- Disturbance and changes in habitat, food supplies, cover, breeding sites, and other habitat components necessary for population maintenance used by any species to a degree that would lead to substantial population change
- Disturbance and change of seasonally important habitat (e.g., critical for overwintering or successful breeding) to a degree that would lead to substantial population change
- Interference with a species’ movement pattern that affects its ability to breed or overwinter successfully to a degree that would lead to substantial population change

Assumptions

This analysis assumes the following:

- NSO stipulations would prevent direct disturbance to habitats and species by restricting surface-disturbing activities where they are applied.
- TL stipulations would help to prevent direct disturbance to species during sensitive periods, such as during winter, when forage is sparse, and during breeding and birthing.

- Disturbance of a key or critical component of a species habitat would be detrimental, with the degree dependent on the importance of the habitat component to the maintenance of the population.
- Habitat conditions and quality are directly linked to the health, vigor, and cover of vegetation communities, as well as to soil conditions and water quality and quantity.
- Habitat disturbance from damaged vegetation, noise, human presence, and increased dust would often displace wildlife beyond the actual disturbance footprint, although some wildlife may adapt over time, depending on the nature of the disturbance and the species being impacted.

3.12.2.3 Common Impacts Associated with Geothermal Development

The information presented in the Common Impacts on Fish and Wildlife Associated with Geothermal Development section of the 2008 Geothermal PEIS (BLM and Forest Service 2008) is incorporated by reference here. Additional information specific to this EIS includes consideration of the particular fish and wildlife species in the project area per alternative below.

3.12.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. Impacts under Alternative 1 would be similar to those described in the 2008 Geothermal PEIS (BLM and Forest Service 2008), although specific impacts would be evaluated on a case-by case basis. Geothermal leasing stipulations and closures specific to fish and wildlife would not be implemented under this alternative; however, any geothermal lease applications and nominations would be subject to standards and guidelines outlined in the Forest Plan and environmental analysis. The Forest Service has determined that the JNRA (approximately 28,900 acres) is excluded from geothermal leasing on the basis of existing laws, regulations (see 43 CFR, Subpart 3201.11), and executive orders. There would be no direct impacts on wildlife in the JNRA under Alternative 1.

3.12.2.5 Impacts Under Alternative 2

Fisheries and Aquatic Biota

Impacts on fisheries from geothermal projects are directly linked to impacts on streams and aquatic habitat, in most cases. Impacts would result primarily from activities occurring near or in water bodies. NSO stipulations described in **Chapter 2** would apply to water bodies, rivers and streams (perennial and intermittent), wetlands, springs, playas, riparian areas, 100-year floodplains, and a 500-foot-wide protection zone surrounding these features. Adjacent ground and streams would not be disturbed directly. The NSO stipulations would reduce or eliminate impacts associated with direct habitat disturbance, such as removal of streamside vegetation.

Indirect impacts on aquatic habitat could occur from groundwater withdrawal from geothermal activities. However, the amount of water to be used during geothermal development is not identified in the RFDS and is not known at this time. Changes in flows of surface waters due to geothermal pumping would be unlikely, because the extracted geothermal groundwater would be returned to the source aquifer via injection wells. Therefore, the volume of groundwater in the source aquifer would not be substantially reduced over the life of the project.

Indirect impacts on aquatic habitat from groundwater withdrawal during geothermal activities are unknown at this time. In future projects the operator will be responsible for obtaining water rights, and the source of this water is not known at this time. Water depletions would be evaluated at a later stage, with USFWS consultation, once more information is known.

Stream flow rates are affected by the upland vegetation and adjacent terrain; therefore, geothermal development could alter stream flows and affect aquatic species and habitat. NSO stipulations would apply to slopes in excess of 40 percent and soils with severe erosion potential. These stipulations would reduce the impacts on aquatic habitat from runoff and sedimentation of streams due to geothermal activity. Surface disturbance and use of heavy machinery and equipment could result in erosion and sedimentation into cold water aquatic habitats; however, these impacts are unlikely to result in a substantial population change.

Wildlife

Wildlife species may be affected by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres of disturbance may occur in wildlife habitat in the project area; however, the location of surface disturbance is unknown at this time. Habitat at drilling pads, facilities, roadways, and transmission corridors would be directly affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development. Geothermal development would have the greatest impact on wildlife if it were to affect specialty habitats, such as riparian areas, wetlands, alpine talus, caves, or wintering and breeding areas. NSO stipulations would apply to several specialty habitats, such as riparian areas, wetlands, and slopes in excess of 40 percent, reducing the likelihood of direct or indirect impacts on wildlife in these areas.

Fragmentation would affect wildlife by altering how wildlife species use the habitat. Fragmentation can separate wildlife populations into smaller populations, making them more vulnerable to predation, drought, and disease and limiting genetic diversity within breeding groups. Movement between habitat tracts is more difficult after fragmentation. Roads have been shown to impede the movements of invertebrates, reptiles, and small and large mammals (Jackson 2000). Habitat fragmentation can create increased edges for access by predators and invasive species and can facilitate access by hunters, reducing the density and diversity of wildlife species found in the original habitat (Andren 1994).

Animals displaced by fragmentation would occupy nearby habitats, which could lead to an increase in competition for resources and result in decreased health and, potentially, death for individuals that are less fit. The impacts resulting from displacement after habitat removal and fragmentation depend on many factors, including the sensitivity of a species to edge and area impacts, the duration and rate of habitat loss and fragmentation, and the proximity of a chosen habitat to the disturbed area (Hagan et al. 1996).

Wildlife would generally avoid areas next to disturbance resulting from geothermal development; therefore, the amount of habitat actually affected by disturbance and fragmentation extends beyond the habitat disturbed. The effective habitat loss (amount of habitat actually used by wildlife) due to new roadways was reported to be 2.5 to 3.5 times as great as actual habitat loss (Reed et al. 1996). During the exploration phase of development, approximately 10 miles of local road, with a width of 12 feet, would need to be widened to about 20 feet to accommodate larger truck traffic. Roads used during exploration would be widened an additional two feet during the development phase. Wildlife habitat fragmentation and disturbance impacts described above could occur along these roadways; however, the exact location and magnitude of impacts are unknown at this time.

Fragmentation can facilitate the spread and introduction of invasive plant species. Roads and other corridors can facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wild or human vectors (Trombulak and Frissell 2000).

Wildlife can be affected by invasive vegetation. Invasive plant species may be unpalatable for native animal species, making it difficult for them to forage. This can alter the population structure of entire habitats. Invasive plants often disperse native vegetation, reducing the quality of the habitat for most wildlife. Birds are most directly affected by invasive plants, as their food source is often seeds from native grasses and shrubs.

Noise from geothermal activities can have impacts on wildlife. Principal sources of noise from geothermal activities include trucks and the operation of drilling rigs and heavy machinery. On the basis of the types of equipment that would likely be used, such as drill rigs and graders, noise levels above 65 dBA would be present at distances of less than 400 feet from binary power plants. Noise levels from production wells would exceed the 65 dBA limit only at a distance of less than 69 feet. Most impacts associated with noise could occur if critical life cycle activities were disrupted, such as mating and nesting. Disturbance during mating, nesting, or rearing can cause wildlife to abandon mating and nesting activities and can strand young, leaving them susceptible to predation and starvation. However, implementing TLs, as described in **Chapter 2**, would limit noise disturbance nesting and breeding periods (March 1 to August 15) and would reduce the likelihood of impacts on seasonally important wildlife habitat.

The location and timing of geothermal activities (especially exploration and development) may affect the migratory and other behavioral activities of some species. Construction activities could affect local wildlife by disturbing normal behavior, such as foraging, mating, and nesting. Wildlife may cease foraging, mating, or nesting or may vacate active nest sites in areas where geothermal activities are occurring; some species may permanently abandon the disturbed areas and adjacent habitats. In addition, exploration and development may affect the movements of some birds and mammals; for example, they may avoid a migratory route because of ongoing construction.

Increased human activity also increases the potential for fires. Fire may affect wildlife through direct mortality, reduced habitat, or reduced habitat quality including reduced forage and cover. BMPs (such as development of a fire management strategy) would minimize the potential for a human-caused fire.

Rocky Mountain Bighorn Sheep

Because all Rocky Mountain bighorn sheep habitat is in the Pecos Wilderness and Cochiti Canyon, and the proposed action would not impact alpine meadow habitat, there would be no impacts on Rocky Mountain bighorn sheep.

Rocky Mountain Elk

Direct and indirect impacts on Rocky Mountain elk would be the same as the impacts described above for wildlife. Up to 674 acres of the approximately 1,424,900 acres of Rocky Mountain elk habitat in the SFNF could be directly impacted by Alternative 2. Constructing access roads could result in indirect impacts on Rocky Mountain elk, including temporal and spatial habitat avoidance. These impacts could occur on approximately 14,320 acres of habitat surrounding roads during times that roads are utilized (Wisdom et al. 2004; Rowland et al. 2000). However, the exact amount of habitat directly or indirectly affected is unknown, because the location of surface-disturbing geothermal development is not known at this time. At most, expected surface disturbance would remove less than 0.05 percent of the available Rocky Mountain elk habitat in the SFNF, and, because population trends are stable, changes in vegetation would have negligible impacts on Rocky Mountain elk habitat and would not lead to a substantial population change.

Merriam's Turkey

Direct and indirect impacts on Merriam's turkey would be the same as the impacts described above for wildlife. Up to 674 acres of the approximately 633,700 acres of Merriam's turkey habitat in the SFNF could be directly impacted by Alternative 2. Indirectly, some habitat could be reduced in quality due to noise or other disturbance. However, the exact extent of habitat directly or indirectly affected is unknown, as the location of surface-disturbing geothermal development activities is not known at this time. At most, expected surface disturbance would remove less than 0.1 percent of the available Merriam's turkey habitat on the SFNF. Because population trends are stable, changes in vegetation would have negligible impacts on Merriam's turkey habitat and would not lead to a substantial population change.

Mourning Dove

Direct and indirect impacts on mourning dove would be the same as the impacts described above for wildlife. Up to 674 acres of the approximately 647,300 acres of mourning dove habitat in the SFNF could be directly impacted by Alternative 2. Indirectly some habitat would be reduced in quality due to noise or other disturbance. However, the exact amount of habitat directly or indirectly affected is unknown, as the location of surface-disturbing geothermal development activities is not known at this time. At most, expected surface disturbance would remove less than 0.1 percent of the available mourning dove habitat on the SFNF. Because population trends are stable, changes in vegetation would have negligible impacts on mourning dove habitat and would not lead to a substantial population change.

Hairy Woodpecker

Direct and indirect impacts on hairy woodpecker would be the same as the impacts described above for wildlife. Up to 674 acres of the up to 84,100 acres of hairy woodpecker habitat in the SFNF could be directly impacted by Alternative 2. Indirectly, some habitat could be reduced in quality due to noise or other disturbance. However, the exact amount of habitat directly or indirectly affected is unknown, as the location of surface-disturbing geothermal development activities is not known at this time. At most, expected surface disturbance would remove less than 0.8 percent of the available hairy woodpecker habitat on the SFNF. Because population trends are stable, changes in vegetation would have negligible impacts on hairy woodpecker habitat and would not lead to a substantial population change.

Rio Grande Cutthroat Trout

In most cases, impacts on RGCT and its habitat from geothermal projects are directly linked to impacts on riparian and wetland habitats. Sediment inputs may affect habitat suitability (particularly spawning habitat, which consists of clean gravel, with little or no fine sediment). NSO stipulations would apply to water bodies, rivers and streams (perennial and intermittent), wetlands, springs, playas, riparian areas, 100-year floodplains, and a 500-foot-wide protection zone surrounding these features. Implementing these measures would protect and maintain streamside vegetation and bank stability in RGCT habitat. In addition, in combination with NSO stipulations for steep slopes and soils with severe erosion potential, the stipulations would reduce the likelihood of sedimentation into occupied RGCT streams. However, indirect impacts associated with sedimentation could still occur.

Indirect impacts on RGCT habitat from groundwater withdrawal during geothermal activities are unknown at this time. In future projects the operator will be responsible for obtaining water rights, and the source of this water is not known at this time. Water depletions would be evaluated at a later stage once more information is known.

There would be no direct impacts on RGCT. Alternative 2 could indirectly impact RGCT habitat but would not reduce available habitat. The impacts on RGCT habitat would not lead to a substantial population change.

Pinyon Jay

Direct and indirect impacts on pinyon jay would be the same as the impacts described above for wildlife. Up to 674 acres of the approximately 250,100 acres of pinyon jay habitat in the SFNF could be directly impacted by Alternative 2. Indirectly, some habitat could be reduced in quality due to noise or other disturbance. However, the exact extent of habitat directly or indirectly affected is unknown, because the location of surface-disturbing geothermal development activities is not known at this time. At most, expected surface disturbance would remove less than 0.3 percent of the available pinyon jay habitat on the SFNF. Because population trends are stable, changes in vegetation would have negligible impacts on pinyon jay habitat and would not lead to a substantial population change.

Mexican Spotted Owl

The types of direct and indirect impacts on MSO would be the similar as the impacts described above for wildlife. However, surface occupancy and use would be prohibited on designated habitat. In these areas, no direct impacts on MSO are anticipated. Indirectly, some habitat could be reduced in quality due to noise or other disturbance; however, the extent and magnitude of these impacts is unknown, as the locations of surface-disturbing geothermal development activities is not known at this time.

Direct and indirect impacts could also occur on potential MSO habitat not designated as critical habitat (late-seral stage mixed conifer vegetation, which constitutes 72,500 acres in the project area). These types of impacts could include direct removal, fragmentation, habitat avoidance, and noise disturbance. Implementing TLs from March 1 to August 31 would protect and limit disturbance from drilling and construction in protected activity centers (PACs) during the critical nesting and breeding period. At most, expected surface disturbance would remove less than 0.9 percent of late-seral stage mixed conifer habitat on the SFNF. Because population trends are stable on the SFNF, the changes in vegetation would have a negligible impact on MSO habitat and would not lead to a substantial population change.

Migratory Birds

Direct and indirect impacts on migratory birds would be the same as the impacts described above for wildlife. Up to 674 acres of the approximately 1,558,500 acres of migratory bird habitat in the SFNF could be impacted by Alternative 2. Expected surface disturbance would remove less than 0.04 percent of the available migratory bird habitat on the SFNF; therefore, changes in vegetation would have negligible impacts on migratory bird habitat.

3.12.2.6 Impacts Under Alternative 3

There would be no lands available for leasing in the project area under Alternative 3. There would be no direct or indirect impacts on fish and wildlife species from geothermal activities under this alternative.

3.12.2.7 Impacts Under Alternative 4

Under Alternative 4, approximately 28,900 acres would be closed to geothermal leasing, while approximately 139,800 acres of the NFS lands in the project area would be allocated as open to geothermal leasing, subject to existing laws, regulations, formal orders, and stipulations. As with Alternative 2, 674 acres could be disturbed in the project area. Direct and indirect impacts on fish and wildlife would be similar to those described under Alternative 2; however, the level of intensity of disturbance could be more severe, specifically for fish and riparian species. This is because stipulations for water bodies and rivers or streams are less restrictive. The potential disturbance on intermittent streams could lead to increased sedimentation flowing into perennial streams and could reduce the quality of habitat for species that are sediment intolerant, such as RGCT and other cold water fish species.

3.12.2.8 Cumulative Impacts

The cumulative impacts analysis region of influence for fish and wildlife is the three level 4 watersheds that intersect the project area: the Rio Grande-Santa Fe, Rio Chama, and Jemez watersheds. Impacts on fish and wildlife do not end at the project area boundary but would encompass migration corridors, large home ranges, and cross boundary landscapes that extend beyond SFNF land.

Past, present, and reasonably foreseeable future actions are discussed in **Section 3.3.4**. They are the following projects, which would increase the amount of disturbance in the cumulative impacts analysis area:

- Building hiking trails for the Continental Divide National Scenic Trail
- Pueblo of Jemez Red Rocks Dam Repair
- Abiquiu Land Grant Waterline Replacement
- McKinney Dam
- Mineral development, including the South Pit Pumice Mine Expansion and the Duran 2010 Pumice Mine

Other projects that would likely restore habitat conditions in the cumulative impacts analysis area are as follows:

- Southwest Jemez Mountains Restoration Project
- Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project
- Pueblo of Jemez Owl Springs Bridge Sediment Removal Project
- New Mexico Meadow Jumping Mouse Critical Habitat Projection Project
- Supplement to the Final EIS for Invasive Plant Control Project

The response of individual species to past, present, and reasonably foreseeable future actions would vary, depending on the life history and habitat needs of the species. However, in general, projects that increase the amount of disturbance could reduce habitat or cover where those projects occur. In addition, ongoing recreation use could result in wildlife habitat avoidance in some areas.

Alternatives 1, 2, and 4 would increase the number of acres of disturbance in the cumulative impacts analysis area, when combined with other past, present, and reasonably foreseeable future actions. However, NSO, CSU, and TL stipulations under Alternatives 2 and 4 would limit impacts in seasonally important habitats (such as perennial and intermittent rivers and streams, and elk calving areas). Timing limitations for special status raptors may also minimize risk to reproductive and post-fledgling success for other migratory birds nesting in those areas.

Geothermal development activities, in combination with other surface-disturbing activities, may increase the potential for nonnative and invasive species to colonize and dominate sites, thus reducing the quality of habitat for some species. However, BMPs identified in Appendix C—and other weed control efforts on the Coyote, Cuba, Espanola, and Jemez Ranger Districts—would reduce or mitigate this impact.

Cumulative impacts on fish and aquatic habitats could include sediment influx in some areas as a result of geothermal development in combination with natural wildfire or flooding. However, stipulations for rivers, streams, and erosive soils under Alternatives 2 and 4 would restrict geothermal development in these areas and limit the amount of sedimentation entering waterways from geothermal specific activities.

Combined with other reasonably foreseeable future actions, no significant cumulative impacts on wildlife and fisheries or their habitat are expected from Alternatives 1, 2, and 4. Alternative 3 would have no cumulative impacts on wildlife and fisheries or their habitat.

3.13 Threatened and Endangered Species and Special Status Species

3.13.1 Affected Environment

This section addresses only federally listed or proposed species and Forest Service sensitive species. No special status species surveys were conducted for this project.

Species listed as endangered under the ESA are those that are “in danger of extinction throughout all or a significant portion of its range” (16 USC, Subsection 1532[6]). A species listed as threatened under the ESA is considered “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range” (16 USC, Subsection 1532[20]). Proposed species for ESA listing are those that were found to warrant listing as either threatened or endangered and were officially proposed as such in a *Federal Register* notice after the completion of a status review and consideration of other protective conservation measures.

Forest Service sensitive species are defined in Forest Service Manual 2670.5 as “those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by 1) significant current or predicted downward trends in population numbers or density, or 2) significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution.” **Table 3-14**, below, shows threatened, endangered, or Forest Service sensitive species on the SFNF and whether each is known to occur in the project area.

Table 3-14. Federally Listed and Region 3 Regional Forester's Sensitive Species on the SFNF

Common Name	Taxon	Species Status[1]	Known to Occur in the Project Area	Occurrence in SFNF[2]
Amphibians				
Northern leopard frog	*Lithobates pipiens*	SS	Yes	D
Jemez Mountain salamander	*Plethodon neomexicanus*	E	Yes	D
Birds				
Northern goshawk	*Accipiter gentilis*	SS	Yes	D
Boreal owl	*Aegolius funereus*	SS	No	D
Burrowing owl	*Athene cunicularia hypugaea*	SS	No	ND
American peregrine falcon	*Falco peregrinus anatum*	SS	Yes	D
White-tailed ptarmigan	*Lagopus leucura*	SS	No	D
Mexican spotted owl	*Strix occidentalis lucida*	T/MIS	Yes	D
Gray vireo	*Vireo vicinior*	SS	Yes	D
Fish				
Rio Grande sucker	*Catostomus plebeius*	SS	Yes	D
Rio Grande chub	*Gila pandora*	SS	Yes	D
Rio Grande cutthroat trout (RGCT)	*Oncorhynchus clarki virginalis*	SS/MIS	Yes	D
Mammals				
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	SS	Yes	D
Gunnison's prairie dog	*Cynomys gunnisoni*	SS	Yes	D
Spotted bat	*Euderma maculatum*	SS	Yes	D
American marten	*Martes americana origenes*	SS	No	D
Goat Peak pika	*Ochotona princeps nigrescens*	SS	Yes[3]	D
American pika	*O. princeps saxatilis*	SS	Yes	D
Cinereus (masked) shrew	*Sorex cinereus cinereus*	SS	Yes	D
Water shrew	*S. palustris navigator*	SS	Yes[4]	D
Preble's shrew	*S. preblei*	SS	Yes	D
New Mexico meadow jumping mouse	*Zapus hudsonium luteus*	E	Yes	D
Clams				
Lilljeborg's pea-clam	*Pisidium lilljeborg*	SS	No	D

Table 3-14. Federally Listed and Region 3 Regional Forester's Sensitive Species on the SFNF

Common Name	Taxon	Species Status[1]	Known to Occur in the Project Area	Occurrence in SFNF[2]
Plants				
Tufted sand verbena	*Abronia bigelovii*	SS	No	S
Greene milkweed	*Asclepias uncialis uncialis*	SS	No	D
Chaco milkvetch	*Astragalus micromerius*	SS	No	S
Pecos mariposa lily	*Calochortus gunnisonii var. perpulcher*	SS	No	D
Yellow lady's-slipper	*Cypripedium parviflorum pubescens*	SS	No	D
Robust larkspur	*Delphinium robustum*	SS	No	ND
Heil's alpine whitlowgrass	*Draba heilii*	SS	No	D
Pecos fleabane	*Erigeron subglaber*	SS	No	D
Wood lily	*Lilium philadelphicum*	SS	No	D
Chama blazingstar	*Mentzelia conspicua*	SS	No	D
Santa Fe (Springer's) blazingstar	*Mentzelia springeri*	SS	Yes	S
Arizona willow	*Salix arizonica*	SS	No	D

Source: Forest Service GIS 2015

[1]E = Endangered under the ESA

T = Threatened under the ESA

SS = Forest Service Region 3 Forester's sensitive species

MIS = Forest Service Region 3 Forester's MIS

[2]D = Documented, reliable, recorded observation in appropriate habitat within the SFNF boundary

S = Suspected, likely to occur based on habitat availability to support individuals/breeding pairs/groups within the SFNF boundary

ND = Not documented or suspected within the SFNF boundary

[3] Biota Information System of New Mexico 2016

[4] Forest Service 2014a

Species known to occur in the project area are discussed in more detail below. Federally listed species observed there are the Jemez Mountain salamander, New Mexico meadow jumping mouse, and MSO. Forest Service sensitive species analyzed below are the Rio Grande sucker, Rio Grande chub, northern leopard frog, northern goshawk, American peregrine falcon, gray vireo, pale Townsend's big-eared bat, spotted bat, Gunnison's prairie dog, Goat Peak pika, American pika, cinereus (masked) shrew, water shrew, Preble's shrew, woodlily, Santa Fe (Springer's) blazingstar, and Arizona willow.

3.13.1.1 Forest Service Species Excluded from Analysis and Rationale

A list of potential occurrence in the project area and within 0.5 mile of it was used for the species exclusion from analysis. Sensitive species that may be affected by the proposed action were identified by evaluating the habitat needs of the listed species against the habitat in the project area. Known occupancy or use by sensitive species was also considered.

The following Forest Service Region 3 sensitive species were excluded from further analysis in this report because the project area is outside the species' range, there is lack of essential habitat in the project area, or the species is not known to occur in the project area.

During the impacts analysis for this report, the proposed action was determined to have no impact on the following species: boreal owl, burrowing owl, bald eagle, white-tailed ptarmigan, American marten, Lilljeborg's pea-clam, tufted sand verbena, Greene milkweed, Chaco milkvetch, Pecos mariposa lily, robust larkspur, Pecos fleabane, and Chama blazing star. The rationale for this no impact determination is included in the SFNF Geothermal Leasing EIS Fish, Wildlife, and Plant Report (Forest Service 2016e).

3.13.1.2 Federally Listed Species

Jemez Mountain Salamander

This salamander can be found in moss-covered talus and under bark and beneath logs and rocks in and near mixed forests of spruce/fir and aspen (Biota Information System of New Mexico 2015). This species occurs underground except during periods of warm seasonal rains. In New Mexico, it is found from 6,990 to 11,270 feet in elevation. It lays its eggs underground.

The Jemez Mountain salamander is restricted to the Jemez Mountains in Sandoval, Los Alamos, and Rio Arriba Counties. More than 90 percent of the recorded observations are on lands administered by the SFNF, with additional populations on Santa Clara Pueblo, in Bandelier National Monument, and in the VCNP. Habitat on the SFNF consists of spruce/fir and aspen between 6,990 and 11,270 feet in elevation. Critical habitat for the Jemez Mountain salamander covering 34,400 acres has been designated in the project area; the Forest Service has recorded 573 observations there (Forest Service GIS 2015).

New Mexico Meadow Jumping Mouse

New Mexico meadow jumping mouse can be found on the ground surface in grassy or weedy meadows in the riparian, mixed-conifer, and spruce/fir vegetation communities. This species appears to use two specific riparian community types: persistent emergent herbaceous wetlands (i.e., beaked sedge and reed canarygrass alliances) and scrub-shrub wetlands (i.e., riparian areas along perennial streams that are composed of willows and alders). This jumping mouse especially uses microhabitats of patches or stringers of tall dense sedges on moist soil, along the edge of permanent water (USFWS 2016). This species has been recorded on the SFNF, including three observations in the project area (Forest Service GIS 2015). Due to the low number of observations, it is uncertain how much potential habitat it occupies. Approximately 800 acres of critical habitat for the New Mexico meadow jumping mouse has been designated in the project area, in the San Antonio Creek and Rio Cebolla areas.

Mexican Spotted Owl

The MSO is federally listed as threatened. It is found from parts of central Colorado and Utah, south through Arizona, New Mexico, and west Texas, then south again through northwestern Mexico to the Mexican state of Michoacán. It has the largest geographic range of the three spotted owl subspecies. Its range extends from the southern Rocky Mountains in Colorado and the Colorado Plateau in southern Utah, southward through Arizona and New Mexico and, discontinuously, through the Sierra Madre Occidental and Oriental to the mountains at the south end of the Mexican Plateau (USFWS 1993). Twenty-one years has passed since the first recovery plan, and total population size is not reliably known (USFWS 2012).

MSO is resident in the mountains of New Mexico, being most regular in the south. It can be found in the San Juan, Jemez, Sangre de Cristo, Mount Taylor, Sandia, Manzano, San Francisco, Tularosa, Mogollon, San Mateo, Pinos Altos, Black, White, Sacramento, Guadalupe, and Animas Mountains (Hubbard 1978). The MSO is threatened by destruction and modification of habitat caused by timber harvest and fires. Fuel accumulation and forests overstocked with trees place MSO habitat at risk to stand-replacing fires. Lack of small-scale, low-intensity ground fires has increased this risk.

MSO has limited distribution across the SFNF. There are historical records from all Ranger Districts, mostly in the Jemez and Pecos/Las Vegas Ranger Districts, where it is found in very specific habitat types.

MSO is most common in mature and old-growth forests throughout much of its range. The most highly sought habitat characteristics are high canopy closure, high stand density, a multi-layered canopy, uneven-aged stands, numerous snags, and downed woody matter. Dominant and co-dominant trees in the main canopy are often 18-inch-diameter breast height or larger, with 18-inch-diameter breast height or greater in the mature and old forest types, best expressed in old-growth mixed-conifer forests (usually more than 200 years old). These characteristics may also develop in younger stands that are unmanaged or minimally managed, especially when the stands contain remnant large trees or patches of large trees from earlier stands (USFWS 1993).

MSO may be found in other vegetation communities, but on the SFNF, they are closely linked to the mixed-conifer and riparian vegetation types, which occur throughout the project area.

In addition to the forested areas, MSO in the Jemez Mountains also occupy canyon habitats, where they are cliff nesters. These canyon habitats range from those with a high degree of forest structure on at least one of the slopes above the canyon wall, to little or no tree cover present; however, typically mixed-conifer habitat is close by.

Since 1988, the SFNF has been surveying for MSO. As new areas were surveyed, the number of PACs also increased as owls were located. PACs are areas measuring 600 acres and are designated to conserve the core use areas of MSO. PACs are designed to protect the nest site, several roost sites, and the closest and highly used foraging sites (Ganey et al. 2014). The number of PACs identified in the SFNF has increased from 19 in 1989 to 50 in 2009; 14 PACs have been identified in the project area. Monitoring of existing PACs to determine occupancy has been sporadic; 17 MSO observations have been recorded in the project area (Forest Service GIS 2015).

3.13.1.3 Fisheries

Rio Grande Sucker

Rio Grande suckers typically occur in middle elevation streams (6,600 to 8,600 feet) of small to large size (Sublette et al. 1990). On the SFNF, Rio Grande sucker are found in low gradient (less than 3.2 percent) stream reaches at elevations from 5,600 to 9,600 feet. Juveniles and adults both prefer glides and pools with mean water column velocities less than 706 cubic feet per second. They favor low- to moderate-gradient riffles and pools below riffles in low-velocity stream reaches. They are usually found over gravel or cobble but can also be in backwater habitats

(USFWS 2013). Rio Grande suckers prefer clear-water streams where periphyton[8] food is common, and they are rarely found in waters with heavy loads of silt and organic detritus (Sublette et al. 1990). In the project area, Rio Grande suckers are found in the Rio Cebolla, Rio Guadalupe, San Antonio Creek, East Fork of the Jemez River, and in the main stem Jemez River. The East Fork of the Jemez River, its the main stem, and half of San Antonio Creek are in the JNRA.

Rio Grande Chub

Rio Grande chub spawn in riffle habitat in the spring and early summer, with peak spawning occurring as water levels are declining from peak flow in the spring. Rio Grande chubs feed on mid-water insects, zooplankton, and small fish. They are generally found in streams less than 2 percent gradient in low-velocity habitats, such as pools, runs, and glides, and are often associated with in-stream woody debris or aquatic vegetation (USFWS 2013). In the project area, Rio Grande chubs are found in the Rio Cebolla, Rio Guadalupe, and in the East Fork and main stem of the Jemez River, both of which are in the JNRA.

Rio Grande Cutthroat Trout

RGCT is a Forest Service Region 3 sensitive species. It was a candidate for federal protection under the ESA from 2008 to 2014, when it was removed from candidacy because listing was determined to be not warranted (79 *Federal Register* 59140-59150, October 1, 2014; NMDGF 2014).

RGCT is one of 14 subspecies of cutthroat trout native to the western United States (Behnke 2002). It is found primarily in clear, cold mountain lakes and streams in Colorado and New Mexico, within the Rio Grande Basin (Sublette et al. 1990). In New Mexico, RGCT exist in mountain streams, primarily in the Sangre de Cristo and Jemez Mountains in the Carson National Forest and SFNF. Isolated populations persist in southern New Mexico on the Gila National Forest in the Black Range (Sublette et al. 1990) and on the Mescalero Apache Indian Reservation in the Tularosa Basin. Conservation populations (those with 10 percent or less hybridization with nonnative trout genes) of RGCT occupy approximately 10 percent of their historical habitat (Alves et al. 2008). In 2013, there were 127 conservation populations range-wide, with four conservation populations in the project area, including Canones Creek, Medio Dia Creek, Rio Cebolla, and Rio Puerco (USFWS 2013).

Streams capable of supporting RGCT are at elevations of 6,000 feet and higher. Historically (circa 1800), 43 percent of RGCT populations occupied streams 8,000 feet or less in elevation (Alves et al. 2008). Currently, only approximately 1.6 percent of the populations are in streams with elevation less than 8,000 feet (Alves et al. 2008). Conservation populations are concentrated in streams with elevations from 9,000 to 10,000 feet. Because RGCT are now restricted to first- and second-order headwater streams that are narrow and small, compared to the larger third- and fourth-order streams they once occupied, the absolute loss of habitat is much greater than stream miles might indicate.

Quality of habitat conditions is generally less than moderate across the SFNF. In high-elevation locations where access is limited by topography and wilderness regulations, stream habitat

[8] A complex mixture of algae, blue-green bacteria, microbes that live off nutrients they scavenge from living hosts or find in dead organic matter, and waste or debris that is attached to submerged surfaces in most aquatic ecosystems.

quality is moderate to excellent. Where poor habitat and water quality conditions occur, the size of RGCT populations is affected. Decreased water quality can be attributed to, but is not limited to, soil compaction, road runoff, bank instability, and pollutant delivery from nonpoint sources. Poor habitat conditions can be attributed to, but are not limited to, a lack of in-stream large woody debris, sediment-filled pools, loss of undercut banks, depletion of beaver populations, lack of side channel development, and poor riparian health.

At the conclusion of 2010, the SFNF had surveyed over 299 miles of stream using the Forest Service Region 3 Stream Habitat Inventory protocol. An analysis of the habitat data collected between 2001 and 2005 shows that streams in the wilderness average 33 pieces of large wood per mile. In similar stream types outside of the wilderness, streams had only 11 pieces per mile, in many cases going several miles without one piece of wood. Other habitat indicators often below standard are as follows:

- Excessive sediment and fines in riffle habitat (greater than 20 percent)
- Stream widening that has led to high water temperatures
- Unstable stream banks
- Too few and small pools with low pool volume
- Lack of side channel development

Since development of the Forest Plan (Forest Service 1987), stream habitat conditions for RGCT have varied from slightly declining to slightly improving. However, three large catastrophic wildfires have severely impacted six important RGCT streams in the SFNF between 2010 and 2011, causing the habitat quality to decline.

The SFNF manages approximately 1,072 miles of perennial stream. Approximately 965 miles were thought to be historically occupied before being stocked with nonnative trout, and all are considered potential habitat in the State-Wide Conservation Agreement. RGCT currently live on 135 miles of perennial stream in the SFNF (NMDGF 2014). In the project area, RGCT are present in 23 miles of stream reaches, including Rio Cebolla, Rio Puerco, Medio Dia Creek, and Canones Creek (Forest Service GIS 2015). All of these creeks are outside of the JNRA.

3.13.1.4 Wildlife

Northern Leopard Frog

This leopard frog ranges in a wide variety of habitats (springs, marshes, wet meadows, riparian areas, vegetated irrigation canals, ponds, and reservoirs) but requires a high degree of vegetation cover for concealment (NatureServe 2009a; Biota Information System of New Mexico 2006). In New Mexico, it is known from approximately 3,600 to 10,000 feet and breeds in ponds or lake edges with fairly dense aquatic emergent vegetation, from April to July and September to October (Degenhardt et al. 1996). The leopard frog attaches its eggs to submerged vegetation well below the surface, in water 1.5 feet deep or more (NatureServe 2009a).

Over-wintering habitats are larger lakes and streams that do not freeze completely during winter (NatureServe 2009a). Suitable habitat is present in the project area.

The northern leopard frog has been documented on the SFNF Cuba, Jemez, Española, and Pecos/Las Vegas Ranger Districts. The species is also suspected to be on the SFNF Coyote District. There are approximately 7,400 acres of potential habitat for northern leopard frog in the project area. This habitat was modeled using the SFNF riparian geospatial information below

10,000 feet in elevation. A total of 28 observations have been recorded in the project area. Due to the low number of observations, it is uncertain how much potential habitat is currently occupied. In 2013, the species was reintroduced as tadpoles on the VCNP (outside of the project area) in two isolated pond locations.

Northern Goshawk

Preferred habitat for the northern goshawk consists of coniferous forests, with a variety of structural stages for nesting and foraging. Forest types occupied by the goshawk in the Southwest are ponderosa pine (74 percent), mixed species (23 percent), and spruce-fir (3 percent; Reynolds et al. 1992). At the nest tree/stand level, nests typically occur in mature to old-growth forests, composed primarily of large trees with high canopy closure, near the bottom of moderate hill slopes, with sparse ground cover (Squires and Reynolds 1997; Squires and Kennedy 2006). Goshawks nested 2.5 times more often than expected in stands with 70 to 79 percent canopy coverage and 5.8 times more often than expected in stands with 80 percent or greater canopy coverage (Squires and Reynolds 1997). The nest site is generally situated within 0.25 mile of a stream or other water source (Squires and Reynolds 1997).

Northern goshawks prey on small- to medium-size birds and mammals, from robins and chipmunks to grouse and rabbit (Reynolds et al. 1992). The best foraging habitat occurs in a mosaic of structural stages scattered across the landscape (Reynolds et al. 1992). In New Mexico, average home range size during the breeding season is 1,400 acres for females and 5,200 acres for males (Squires and Reynolds 1997).

Suitable nesting and foraging habitat for northern goshawk is found in the ponderosa pine and spruce/fir vegetation communities in the project area. Post-fledgling family areas are surrounding a nest area that is defended by a goshawk pair. The project area contains 14 known post-fledgling family areas, covering a total of 7,900 acres (**Table 3-15**). Nineteen observations have been recorded in the project area.

Table 3-15. Northern Goshawk Post-Fledgling Family Areas in the Project Area

Post-Fledgling Family Area Name	Year of Occupancy	Acres
Barley	1992	500
Calaveras	1993	400
Cerro Pavo	1992	700
Cerro Pelado	1992	600
Cerro Pelon	1989	4,100
El Cajete	1991	600
Horseshoe	1984	600
Las Conchas	1992	600
Monument	1991	600
Pony Canyon	1991	600
Redondo	1989	500
Rio Cebolla	1995	600
San Juan Canyon	1991	600
San Juan Mesa	1991	600

Source: Forest Service GIS 2015

Boreal Owl

The boreal owl occurs mainly above 9,500 feet in spruce/fir forests. Surveys through 1996 showed this species to be resident in very small numbers in spruce/fir habitat in the Jemez Mountains. As of 1996 no boreal owls have been observed south of the Valles Caldera, but individuals have been observed in the Valles Caldera, next to the project area (Forest Service 2014a).

Approximately 9,600 acres of spruce/fir forest are present in the project area, some of which are above 9,500 feet in elevation. These forests may provide suitable habitat for the boreal owl in the project area, and this species may be present but not recorded by the Forest Service.

American Peregrine Falcon

There are approximately 237,600 acres of designated peregrine falcon suitable breeding habitat zones on the SFNF, 3,100 acres of which are in the project area. There are four designated suitable breeding habitat zones completely within the boundaries of the project area: R26, R29, R39, and R44. A peregrine falcon territory is an area surrounding a nest that is defended by a falcon pair. Statewide surveys conducted from 2008 to 2010 found that 84 percent of the 174 peregrine falcon territories were occupied. Populations increased dramatically from 1980 to 2007, then remained stable or declined slightly by 2010 (Biota Information System of New Mexico 2016).

Suitable habitat for American peregrine falcon includes various open habitats, from grassland to forested areas, in association with suitable nesting cliffs (NatureServe 2009b). In New Mexico, the breeding territories of peregrine falcon center on cliffs that are in wooded/forest habitats, next to large expanses of foraging areas (Biota Information System of New Mexico 2008). The falcon often nests on ledges or potholes on the face of rocky cliffs or crags (Biota Information System of New Mexico 2008). Ideal locations include undisturbed areas with a wide view, near water, and close to plentiful prey. Foraging habitats of woodlands, open grasslands, and water bodies are generally associated with the nesting territory (NatureServe 2009b). Suitable nesting and foraging habitat is in the project area.

Prey consists almost entirely of birds, ranging in size from swallows to large shorebirds. In New Mexico, jay, woodpecker, swift, mourning dove (*Zenaida macroura*), and pigeon (*Columbo livia*) are commonly taken as prey species (Biota Information System of New Mexico 2008). Falcons are known to forage over large areas, often 10 to 15 miles from the nest.

Gray Vireo

The gray vireo is a scrub-foraging inhabitant of some of the hottest, most arid regions of the southwestern United States and adjacent parts of northwestern Mexico. The vireo is a short-distant migrant, withdrawing from breeding habitat by August (early fall) and returning in late April to early May (NMDGF 2006). Breeding habitat in northern and northwestern parts of New Mexico is found at elevations from 5,500 to 7,200 feet, in broad-bottomed canyons (flat or gently sloped valleys), below or near ridgetop/rock outcrop/cliff head wall of canyon, or gently sloped bowls in pinyon-juniper woodlands (NatureServe 2006; NMDGF 2006). The vireo is most often associated with juniper, pinyon pine, or oak trees, with a wide variety of shrubs and grasses (NMDGF 2006, 2007). Habitat usually contains a mixture of open savannas and slightly more closed-canopy woodland areas (NatureServe 2006; NMDGF 2006). Trees in habitat areas are generally mature, ranging from 12 to 25 feet in height (NatureServe 2006).

Gray vireos are insectivorous, taking grasshopper, stinkbug (*Eleodes* spp.), treehopper, cricket, moth, damselfly, cicada, and caterpillar. The vireo is a thicket forager, taking most prey from leaves, twigs, branches, and trunks of small trees or twigs and branches of shrubby vegetation. Territory size varies in part with population density, ranging from 5 to 17 acres (NMDGF 2007).

The gray vireo is found throughout New Mexico west of the Great Plains, but with an extremely patchy distribution often composed of small sites (NMDGF 2006, 2007a). Breeding Bird Survey data showed a significantly increasing trend for gray vireos range-wide during the 1980s and 1990s; however, this may, in part, reflect increased ability by survey personnel to detect this easily overlooked species (New Mexico Partners in Flight 2007). Current range-wide Breeding Bird Survey data still show an increasing trend, but there is insufficient sample size and data quality for a reliable estimate to be made. Breeding Bird Survey coverage of this species in New Mexico is minimal. The highly negative trend shown for New Mexico reflects a drop in detections on a small number of routes in the northwest part of the state. On the SFNF, the gray vireo is documented on the Jemez and Española Ranger Districts and is suspected on the Coyote, Cuba, and Pecos/Las Vegas Ranger Districts. Individuals and a pair of birds were detected during surveys on the SFNF in 2010.

There are approximately 192,600 acres of potential habitat for the gray vireo on the SFNF, 9,200 acres of which are in the project area. This habitat was modeled using pinyon-juniper vegetation communities between 5,500 and 7,200 feet in elevation. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

Pale Townsend's Big-Eared Bat

Although pale Townsend's big-eared bat occurs in a wide variety of habitats, its distribution tends to be geomorphically[9] determined and is strongly correlated with the availability of caves or cave-like roosting habitat, such as old mines. Population concentrations occur in areas with substantial surface exposures of cavity-forming rock, such as limestone, sandstone, gypsum, or volcanic (Pierson et al. 1999). Individuals or small groups of three to five bats may day roost in hollow and creviced trees and snags for a limited time.

Populations appear to be quite sedentary, with marked animals (all females) not known to move more than a few miles from their birth roost. Studies suggest that movement in the nursery season, whether for foraging or shifting to an alternate roost, are confined to within 9.3 miles of the primary roost (Pierson and Rainey 1998). The most significant roosts are those with large congregations of bats, summer maternity roosts, and winter hibernacula (Pierson et al. 1999). These sites are highly sensitive to disturbance and human interference.

Foraging occurs after dark in a variety of habitats, including open and forested areas. The bat forages in tree canopies and gleans insects from vegetation. It can forage up to 8 miles from day roosts but tends to forage within a few miles of colonial roosts (Pierson et al. 1999). Suitable roosting and foraging habitat is in the project area.

Threats are habitat loss, cave vandalism disturbance by cave explorers at maternity and hibernation roosts (Pierson et al. 1999; Biota Information System of New Mexico 2006), and the spread of white-nose syndrome, which affects hibernating bats. Named for the white fungus that appears on the muzzle and other body parts of hibernating bats, white-nose syndrome is associated with extensive mortality of bats in eastern North America. First documented in New

[9] Related to or resembling the earth's surface

York in the winter of 2006/2007, white-nose syndrome has spread rapidly across the eastern United States and Canada, and the fungus associated with white-nose syndrome has been detected as far west as Oklahoma. White-nose syndrome has not been documented in New Mexico.

There are approximately 302,600 acres of potential habitat for the pale Townsend’s big-eared bat on the SFNF, 6,200 acres of which are in the project area. This habitat was modeled using information on geologic formations that are known for producing cave and rock crevice habitat. While mines provide artificial habitat for the pale Townsend’s big-eared bat, there is insufficient information on bat use of abandoned mines on the SFNF; therefore, mines were not used for this analysis. An individual was captured during studies in 1998 in the vicinity of the project area, indicating a low density in the Jemez Mountains (Bogan et al. 1998). It is uncertain how much potential habitat it currently occupies.

Spotted Bat

Spotted bats have been recorded in a variety of habitats, including riparian, pinyon-juniper, ponderosa pine, mixed-conifer, and spruce-fir forest. Most records are from forested areas. This bat occurs between 3,900 and 10,600 feet in New Mexico. It is suggested that it is a resident of the ponderosa pine area in June and July and moves to lower elevations in late summer and autumn. Those captured in the Jemez Mountains were netted over streams or water holes in ponderosa or mixed-coniferous forest (Bogan et al. 1998). They are cliff dwellers that roost in cracks and crevices in rock. The bat’s diet consists predominantly of moths but also includes katydids, grasshoppers, and flies (Biota Information System of New Mexico 2006; NMDGF 2006).

This species is fairly rare throughout its range, indicating that its scarcity in New Mexico may be due to biology rather than other impacts (NMDGF 2006). There are approximately 76,900 acres of potential habitat for the spotted bat on the SFNF, 7,500 acres of which are in the project area. Due to the species rarity and low number of observations, it is uncertain how much potential habitat it currently occupies. Suitable roosting and foraging habitat is in the project area.

Gunnison’s Prairie Dog

Gunnison’s prairie dog is found in grassland and shrub-steppe habitat, at elevations ranging from semi-desert to montane (NMDGF 2008). In New Mexico, Gunnison's prairie dog may occur from approximately 4,500 to 10,000 feet in elevation. The species is found in montane grassland, juniper savanna, plains-mesa grassland, Great Basin desert scrub, plains-mesa sand scrub, and desert grassland vegetation in New Mexico, as well as in urban and cultivated areas (NMDGF 2008). A large complex of Gunnison’s prairie dog in the VCNP, next to the project area, constitutes a focal area for the species. Approximately 8,000 acres of potentially suitable habitat is in the project area, and six incidental observations were recorded there. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

American Marten

American marten prefers late successional stands of mesic, conifer-dominated forest. It occurs between 7,000 to 13,000 feet, mostly above 9,000 feet. Optimum habitat appears to be mature old-growth spruce/fir, with more than 30 percent canopy cover, abundant fallen logs and stumps, and lush shrub and forb vegetation to support prey species. These are mice, voles, insects, red squirrels, and snowshoe hare. It also feeds on carrion, birds, and bird eggs. It is sensitive to changes in habitat, including timber harvest, snag removal, and firewood collection. Martens den in tree cavities, logs, rock piles, and burrows (Forest Service 2014a).

American marten have been documented on the Espanola and Pecos/Las Vegas Ranger Districts and suspected on the Jemez District of the SFNF. There have been no recorded observations in the project area, but there have been sightings on the northwestern corner of the VCNP, next to the project area. American marten home ranges from these sightings would most likely overlap with the project area. Due to no recorded observations, it is uncertain how much potential habitat it currently occupies.

Goat Peak Pika

Goat Peak pika is confined to talus slides and boulder fields in alpine and subalpine areas. Optimal habitat for the pika is the talus/meadowland ecotone, with grass growing between the rock slabs. Temperature is a limiting factor for Goat Peak pika. The temperature within representative talus habitat ranges from -10 to 53°F, with temperatures 2 feet above the ground ranging from -13 to 72°F. Pikas cannot tolerate an ambient air temperature in their immediate environment of 82°F for more than two hours.

In the Jemez Mountains, Goat Peak pikas have been observed on Goat, Santa Clara, and Pelado Peaks, where they live in lava rocks as low as 9,000 feet (Biota Information System of New Mexico 2016). Goat Peak pikas occupy virtually every patch of appropriate talus in the Jemez Mountains. Specimens have been collected from Chicoma Mountain, Pajorito Mountain, Cerro Grande, Rabbit Mountain, the head of Frijoles Creek, Redondo Peak, and Cerros del Abrigo. Additional sightings have been made on Cerro Toledo and Shell Mountain (Biota Information System of New Mexico 2016). There are approximately 7,400 acres of potential habitat for the Goat Peak pika on the SFNF, 200 acres of which are in the project area. This habitat was modeled using alpine and subalpine communities above 9,000 feet in elevation. Goat Peak pikas have been recorded at Pelado Peak, Rabbit Mountain, and Frijoles Creek in the project area.

American Pika

American pika is rather narrowly restricted to mountainous areas, where talus slopes provide suitable cover. In New Mexico, American pikas live from above the timberline, down into subalpine forest. Occasional exceptional animals are found living under piles of boards or timbers or in burrows (probably made by other mammals), but broken rock (including mine tailings) is the usual habitat. The rock must be sufficiently large that the spaces between provide corridors for movement; the slide must be of sufficiently recent origin that the spaces have not filled with debris from higher ground. In the best habitat the talus is interspersed with meadow vegetation (Biota Information System of New Mexico 2016).

In New Mexico, American pikas are confined to talus slides and boulder fields in alpine and subalpine areas. They are common in the alpine area of the Sangre de Cristo Range, descending as low as 11,000 feet. There are approximately 86,400 acres of potential habitat for the American pika on the SFNF, less than 100 acres of which are in the project area. One occurrence of American pika has been recorded in the project area.

Cinereus (Masked) Shrew

In New Mexico, this shrew is confined primarily to riparian habitats in subalpine coniferous forest in the Sangre de Cristo, Jemez, and San Juan Mountains, usually above 9,500 feet. This species has been found along the banks of cold streams, in springy meadows, or under logs in the cold spruce woods.

There are approximately 268,500 acres of potential habitat for cinereus shrew on the SFNF, 23,100 acres of which are in the project area. This habitat was modeled by including high-elevation areas (above 9,000 feet in elevation), including ponderosa pine and white fir vegetation communities on the west side of the SFNF. Five observations have been recorded in the project area (Forest Service GIS 2015). Due to the large area modeled and the fact that more than 75 percent of the observations fell within the modeled habitat, most of the modeled habitat is assumed to be sparsely occupied.

Water Shrew

According to current records in New Mexico, water shrews are confined to the Sangre de Cristo, San Juan, and Jemez Mountains. It occurs near permanent streams, seldom descending below 8,000 feet in elevation. The water shrew can swim with great facility, diving under water to pursue aquatic organisms, and can run across the surface of the water for a short distance (Findley 1987). It eats large quantities of invertebrates daily, such as earthworms and spiders.

On the SFNF, the water shrew has been documented on all Ranger Districts. It is widespread in the Jemez Mountains, although it is not common (Frey 2004). Known capture sites on the Jemez Ranger District are near Fenton Lake, Rio Cebolla, and San Antonio Creek. There are approximately 76,900 acres of potential habitat for water shrew on the SFNF, 7,500 acres of which are in the project area. It is uncertain how much potential habitat it currently occupies, though approximately a third of the observations fell within the modeled habitat. Water shrews have been observed along San Antonio Creek in the project area.

Preble’s Shrew

The species can be found near permanent or intermittent streams, in arid to semiarid shrub or grasslands, and to a lesser extent in dense high-elevation coniferous forests. In general, its habitats are confined to riparian or riparian-like (e.g., springs and seeps) conditions (Cornely et al. 1992). Little is known about its food sources, but it probably forages on small, soft-bodied invertebrates found in riparian areas. There are approximately 76,900 acres of potential habitat for Preble’s shrew on the SFNF, 7,500 acres of which are in the project area. Six incidental observations have been recorded there. Due to a low number of observations, how much potential habitat it currently occupies is uncertain.

3.13.1.5 Plants

Yellow Lady’s Slipper

The yellow lady’s slipper is a perennial deciduous herb that grows as a single plant or in a colony. It grows in moderate shade to nearly full sun in fir, pine, and aspen forests from 6,000 to 9,500 feet in elevation. It most often grows just above the banks of streams, usually 150 to 300 feet from water. This species grows on mesic slopes up to 60 degrees, facing east to northeast, and covered with lush growth less than a foot tall (Forest Service 2014a).

This species is known from San Miguel, Los Alamos, San Juan, and Santa Fe Counties (Forest Service 2014a). There is no modeled habitat for it in the project area, and there are no recorded observations there, but yellow lady’s slipper has been observed in the Valle Caldera National Preserve, next to the project area. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies and if suitable habitat is in the project area.

Heil's Alpine Whitlowgrass

Heil's alpine whitlowgrass is a perennial herb found scattered in small populations in northern New Mexico. This species is found in alpine tundra growing in association with other low growing, cushion-shaped alpine plants. This species occurs at elevations from 12,100 feet and higher. It is known from Rio Arriba and Mora Counties (NMRPTC 1999). It has not been recorded in the project area but has been recorded on the Bandelier National Monument next to the project area, and there may be suitable habitat in the project area. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

Woodlily

The woodlily is a perennial herb found scattered in small populations in northern New Mexico. It prefers wetter sites, in mixed conifer forests with a lush understory, often associated with large aspen, Douglas-fir, or ponderosa pine. Less frequently this species can be found along streams or in meadows (Forest Service 1990). It prefers soils that are rich and well drained. This species is known from San Miguel, Los Alamos, Sandoval, Otero, Rio Arriba, and Santa Fe Counties (Forest Service 2014a). It has not been recorded in the project area, but it contains approximately 4,700 acres of potentially suitable habitat. Potentially suitable habitat both within the project area and surrounding areas has undergone significant reductions due to wildfires. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

Santa Fe Blazingstar

Santa Fe blazingstar is a perennial herb, with numerous branches 1.0 to 1.5 feet long. Its yellow flowers open in late afternoon in July through August. This species occurs in volcanic pumice and unconsolidated pyroclastic ash in pinyon-juniper woodland and lower montane coniferous forests, from 7,000 to 8,000 feet in elevation (NMRPTC 1999). This species is narrowly endemic to loose, volcanic substrate of the Jemez Mountains and is often seen where roads cut through pumice.

The Santa Fe blazingstar is known in Los Alamos, Sandoval, and Santa Fe Counties, New Mexico. Modeled habitat was taken from the SFNF's Terrestrial Ecological Unit Inventory geospatial information for volcanic soils between 7,000 and 8,000 feet in elevation (approximately 15,500 acres of potential habitat on the SFNF, 5,600 acres of which are in the project area). The Santa Fe blazingstar has been documented in three locations in the project area, with a total of 0.49 acre of occupied habitat recorded. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

Arizona Willow

Arizona willow is a perennial shrub forming a prostrate mat, large hedge, or thicket up to 9 feet tall. The plant's flowers open in late May through June. This species occurs in sedge meadows and wet drainage ways in subalpine coniferous forests, from 10,000 to 11,200 feet in elevation (NMRPTC 1999). Habitat often occurs as a narrow, linear strip associated with perennial water in seeps, springs, stream sides, and wet meadows. This species is known from locations in New Mexico, Arizona, and Utah. Arizona willow is known in Rio Arriba, Taos, and Mora Counties, New Mexico. The Forest Service has not documented it in the project area, where there is approximately 100 acres of potentially suitable habitat. Due to a low number of observations, it is uncertain how much potential habitat it currently occupies.

3.13.2 Environmental Consequences

3.13.2.1 Scoping Comments on Resource

The following issues specific to threatened and endangered species and special status species were identified during the public scoping period:

- What are the impacts of geothermal leasing on the Mexican spotted owl, Jemez Mountain salamander, New Mexico meadow jumping mouse, Jemez woodland snail, RGCT, and other threatened and endangered or special status species in the project area? What stipulations and mitigation measures are necessary to protect these species?
- Would geothermal leasing displace other resource uses on the forest, such as recreation and livestock grazing, into or near threatened and endangered species or special status species' habitats?

3.13.2.2 How Resource Impacts Were Evaluated

Method

The method for determining special status species impact is incorporated by reference from the 2008 Geothermal PEIS (BLM and Forest Service 2008). The analysis presented is largely qualitative, due to the lack of data or uncertainty in existing data on special status species in the project area. Since most special status species are associated with specific vegetation communities, the impacts on vegetation described in **Section 3.11** would also likely impact special status species. In addition, many of the impacts on fish and wildlife associated with geothermal development described in **Section 3.12** would also apply to special status species.

Indicators

Indicators of impacts on special status species are as follows:

- Change in acres of habitat potentially suitable for threatened and endangered and special status species
- Change in acres of habitat occupied by threatened and endangered and special status species
- Change in number of threatened and endangered and special status species populations
- Change in acres of rare plant associations
- Change in number of special status wildlife detections

Assumptions

This analysis assumes the following:

- NSO stipulations would minimize direct disturbance to habitats and species by restricting surface-disturbing activities where they are applied.
- TL stipulations would help to prevent direct disturbance to species during sensitive periods, such as winter, when forage is sparse, and during breeding and birthing.
- Disturbance of a key or critical component of a species habitat would be detrimental, with the degree dependent on the importance of the habitat component to the maintenance of the population.
- Impacts on special status species would be more significant than impacts on common species because population viability is already uncertain for special status species.

- The Forest Service would consult with the USFWS for any actions that could affect any federally listed endangered, threatened, or proposed species.

3.13.2.3 Common Impacts Associated with Geothermal Development

The information presented in the Common Impacts on Special Status Species Associated with Geothermal Development section of the 2008 Geothermal PEIS (BLM and Forest Service 2008) is incorporated by reference. Additional information specific to this EIS includes consideration of the particular special status species and habitats found in the project area.

Due to the inability to predict the location, scope, scale, and timing of future development, the impact analysis below provides a general description of common indirect impacts on threatened and endangered and special status species from geothermal resource development. Geothermal exploration, drilling operations, utilization, and reclamation and abandonment could affect threatened, endangered, and sensitive species in the same manner that vegetation, wildlife, and aquatic resources could be affected (see **Section 3.12**, Fish and Wildlife).

Special status species could be affected as a result of

- Habitat disturbance
- Introduction of invasive vegetation
- Injury or mortality
- Erosion and runoff
- Fugitive dust
- Noise
- Exposure to contaminants
- Interference with behavioral activities

Which species may be at risk to construction-related impacts would depend on the project location and specific habitat at or near the site.

An important distinction about impacts on special status species is that those on small localized areas or those affecting only a few individuals can have impacts on special status species. Many special status species depend on unique habitats or have small remaining populations. Impacts that directly affect these unique habitats or individuals, even when small, can have significant impacts on special status species.

3.13.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analyses, in accordance with the Forest Plan and existing laws and regulations.

Geothermal leasing stipulations and closures specific to threatened and endangered species or other special status species would not be implemented; however, any geothermal lease applications and nominations would be subject to standards and guidelines outlined in the Forest Plan and environmental analysis. The Forest Service has determined that the JNRA (approximately 28,900 acres) is excluded from geothermal leasing on the basis of existing laws, regulations (see 43 CFR, Subpart 3201.11), and executive orders. There would be no direct disturbance to threatened, endangered, or sensitive species in the JNRA under Alternative 1.

Elsewhere, the types of impacts that could occur on threatened and endangered and special status species are those described under *Common Impacts Associated with Geothermal Development*.

3.13.2.5 Impacts Under Alternative 2

Federally Listed Species

Jemez Mountain Salamander

Jemez Mountain salamander may be affected by habitat alteration, removal, reduction, or fragmentation. No surface occupancy stipulations would apply to any designated critical habitat for this species. There are approximately 34,400 acres of critical habitat for Jemez Mountain salamander in the project area, and it may also be present outside of designated critical habitat in the aspen and spruce/fir vegetation communities.

NSO stipulations would be in place outside of critical habitat as well, as outlined in **Chapter 2**. Under Alternative 2, NSO stipulations would apply to approximately 132,900 acres in the project area. Up to 674 acres of disturbance is anticipated in the RFDS in the project area; any disturbance that occurs in Jemez Mountain salamander habitat outside of designated critical habitat would reduce the number of acres of suitable habitat available. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development.

Fragmentation would affect Jemez Mountain salamander by altering how it uses the habitat. Fragmentation can separate populations into smaller populations, making them more vulnerable to predation, drought, and disease and limiting genetic diversity within breeding groups. Movement between habitat tracts is more difficult after fragmentation. Roads have been shown to impede the movements of invertebrates, reptiles, and small and large mammals (Jackson 2000). Habitat fragmentation can create increased edges for access by predators and invasive species (Biota Information System of New Mexico 2015).

Disturbance in occupied habitat could lead individuals to move into adjacent habitat that may be at or near carrying capacity. Increased concentrations in adjacent habitat could lead to an increase in the spread of diseases transmitted from humans, such as *Batrachochytrium dendrobatidis*, a fungal disease in northern New Mexico.

Direct injury and mortality could occur as a result of geothermal development associated with the RFDS. Equipment used for clearing vegetation, roadways, well pads, and facility sites and vehicles used during operation and closeout would affect wildlife, such as the Jemez Mountain salamander, which are not mobile enough to avoid construction operations.

New Mexico Meadow Jumping Mouse

Impacts on New Mexico meadow jumping mouse from geothermal projects are directly linked to impacts on riparian and wetland habitats, in most cases. Impacts would result primarily from activities occurring near or in water bodies.

NSO stipulations would apply to the following features, including a 500-foot-wide protection zone surrounding each feature:

- Water bodies

- Rivers and streams (perennial and intermittent)
- Wetlands, springs, and playas
- Riparian areas
- 100-year floodplains

Disturbance of adjacent ground and direct stream disturbance would not occur.

The NSO stipulations would reduce or eliminate impacts from ground disturbance, vegetation removal, road construction and excavation, the installation of structures and other facilities (e.g., transmission towers or pipelines), and water contaminants release. There would be no reduction in the acres of suitable habitat available for New Mexico meadow jumping mouse. NSO stipulations would apply to any designated critical habitat for New Mexico meadow jumping mouse. Approximately 800 acres of critical habitat have been designated in the San Antonio Creek and Rio Cebolla areas in the project area. Potential habitat occurs beyond designated critical habitat (such as along the upper Rio Cebolla); however, development in these areas would be restricted due to the riparian area stipulations. Direct and indirect impacts on New Mexico meadow jumping mouse would not occur as a result of Alternative 2.

Mexican Spotted Owl

MSO may be impacted by habitat alteration, removal, reduction, or fragmentation. NSO stipulations would apply to any MSO-designated critical habitat. Approximately 12,998 acres of MSO critical habitat have been designated in the project area. Up to approximately 674 acres of disturbance is anticipated in the RFDS in the project area, and any disturbance that occurs in MSO habitat outside of designated critical habitat would reduce the number of acres of suitable habitat available. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development.

Noise from geothermal activities can have impacts on MSO. Principal sources of noise from geothermal activities would be trucks, drilling rigs, and heavy machinery. The most impacts associated with noise could occur if critical life cycle activities (e.g., mating and nesting) were disrupted. Disturbance during mating, nesting, or rearing of young can cause MSO to abandon mating and nesting activities and can strand young, leaving them susceptible to predation and starvation.

On the basis of the types of equipment that would likely be used, such as drilling rigs and graders, the noise levels at distances of less than 400 feet from binary power plants would be above 65 dBA. Noise levels from production wells would exceed the 65 dBA limit only at a distance of less than 69 feet.

The location and timing of geothermal activities (especially exploration and development) may affect the migratory and other behavioral activities of MSO. They may cease foraging, mating, or nesting or may vacate active nest sites in areas where geothermal activities are occurring; MSO may permanently abandon the disturbed areas and adjacent habitats. In addition, exploration and development may affect movements; for example, they may avoid a localized migratory route because of ongoing construction. However, drilling and construction would be prohibited between March 1 and August 31 in MSO-designated PACs. Implementing TLs in designated PACs would minimize impacts on MSO during critical nesting and breeding periods.

Fisheries and Aquatic Biota

Impacts on Rio Grande sucker, Rio Grande chub, RGCT, and northern leopard frog from geothermal projects are directly linked to impacts on riparian and wetland habitats, in most cases. Impacts would result primarily from activities near or in water bodies. The East Fork and main stem of the Jemez River and San Antonio Creek are in the JNRA, which is closed to geothermal development, so direct impacts from geothermal development in these streams would not occur.

NSO stipulations would apply to the following features, including a 500-foot-wide protection zone surrounding each feature:

- Water bodies
- Rivers and streams (perennial and intermittent)
- Wetlands, springs, and playas
- Riparian areas
- 100-year floodplains

Disturbance of adjacent ground and direct stream disturbance would not occur.

The NSO stipulations would reduce or eliminate impacts from ground disturbance, vegetation removal, road construction and excavation, the installation of structures and other facilities (e.g., transmission towers or pipelines), and water contaminants release. There would be no reduction in the acres of suitable habitat available for aquatic species.

Indirect impacts on aquatic habitat from groundwater withdrawal during geothermal activities are unknown at this time. In future projects the operator will be responsible for obtaining water rights, and the source of this water is not known at this time. Water depletions would be evaluated at a later stage, with USFWS consultation, once more information is known.

Stream flow rates are affected by the upland vegetation and adjacent terrain; therefore, geothermal development could alter stream flows and affect aquatic species and habitat. NSO stipulations would apply to slopes in excess of 40 percent and soils with severe erosion potential. These stipulations would reduce the impacts on aquatic habitat from runoff and sedimentation of streams due to geothermal activity.

Alternative 2 may impact individual Rio Grande sucker, Rio Grande chub, RGCT, and northern leopard frog; however it is not likely to result in a trend toward federal listing of these species or loss of species viability.

Riparian Mammals

In most cases, impacts on water shrew and Preble’s shrew from geothermal projects are directly linked to impacts on riparian and wetland habitats. Impacts would result primarily from activities occurring near or in water bodies. The East Fork and main stem of the Jemez River and San Antonio Creek are in the JNRA, which is closed to geothermal development, so direct impacts from geothermal development in these streams would not occur.

NSO stipulations would apply to the following features, including a 500-foot-wide protection zone surrounding each feature:

- Water bodies

- Rivers and streams (perennial and intermittent)
- Wetlands, springs, and playas
- Riparian areas
- 100-year floodplains

Disturbance of adjacent ground and direct stream disturbance would not occur.

The NSO stipulations would reduce or eliminate impacts from ground disturbance, vegetation removal, road construction and excavation, the installation of structures and other facilities (e.g., transmission towers or pipelines), and water contaminants release. There would be no reduction in the acres of suitable habitat available for riparian species.

Alternative 2 may impact individual water shrew and Preble's shrew, but it is not likely to result in a trend toward federal listing of these species or loss of species viability.

Raptors and Migratory Birds

Northern goshawk, boreal owl, American peregrine falcon, and gray vireo may be affected by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres may be disturbed in raptor and migratory bird habitat in the project area and may reduce the number of acres of suitable habitat available. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development.

Geothermal development would have the greatest impact on raptors and migratory birds if it were to affect specialty habitats, such as riparian areas, wetlands, cliffs, tall trees, or nesting areas. NSO stipulations would apply to several specialty habitats, such as riparian areas and wetlands.

The direct injury and mortality of raptors and migratory birds may occur as a result of geothermal development associated with the RFDS. Equipment used for clearing vegetation and roadways, well pads, and facility sites and vehicles used during operation and closeout would affect migratory birds nesting in the areas of proposed disturbance. Wildfire could remove acres of suitable habitat for raptors and migratory birds and could reduce the quality of remaining habitat.

Noise from geothermal activities can have impacts on raptors and migratory birds. The principal sources of noise are trucks, drilling rigs, and heavy machinery. The most impacts associated with noise could occur if critical life cycle activities were disrupted (e.g., mating and nesting). All birds could be disturbed by noise. Disturbance during mating, nesting, or rearing of young can cause birds to abandon mating and nesting activities and can strand young, leaving them susceptible to predation and starvation.

However, TLs are proposed in northern goshawk post-fledgling areas, with drilling and construction prohibited between March 1 and September 30, and in peregrine falcon nesting areas, with drilling and construction prohibited between March 1 and August 15. These measures would minimize risks to northern goshawk and peregrine falcon reproductive and post-fledgling success during the critical nesting and breeding period.

Raptors and migratory birds could also be affected by light pollution. Increased illumination may extend diurnal[10] or crepuscular[11] behaviors into the nighttime environment by improving an animal's ability to orient itself. However, constant artificial night lighting may also disorient or entrap birds accustomed to navigating in a dark environment, which may affect foraging, reproduction, communication, and other behaviors (Longcore and Rich 2004). The BMPs identified in Appendix C include efficient facility light design, such that upward light scattering is minimized. These measures would minimize potential impacts on migratory birds associated with light pollution.

Alternative 2 may impact individual northern goshawk, boreal owl, American peregrine falcon, and gray vireo, but it is not likely to result in a trend toward federal listing or loss of species viability.

Bats

Pale Townsend's big-eared bat and spotted bat may be affected by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres may be disturbed in bat habitat in the project area, which may reduce the number of acres of suitable habitat available. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. Geothermal development would have the greatest impact on bats if it were to affect specialty habitats, such as riparian areas, wetlands, rock outcrops, caves, and tree roosting areas. NSO stipulations would apply to several specialty habitats, such as riparian areas, wetlands, and slopes in excess of 40 percent (accounting for rock outcrops and cliffs).

The direct injury and mortality of bats may occur as a result of geothermal development associated with the RFDS. Bat mortalities could occur by colliding with vehicles or structures associated with geothermal development. Shining lights downward can reduce the risk of impacts on bat species; implementing such BMPs as installing shrouds, properly directing light to illuminate only necessary areas, and installing motion sensors to illuminate areas only when necessary, would minimize upward light scattering.

Noise from geothermal activities can have impacts on bats. The principal sources of noise would be trucks, drilling rigs, and heavy machinery. The most impacts associated with noise could occur if critical life cycle activities were disrupted (e.g., mating and foraging). Bats use sound in order to forage, and increased noise can affect their ability to find food through echolocation.

On the basis of the types of equipment that would likely be used, such as drill rigs and graders, the noise levels associated with the equipment would be elevated to levels that could potentially disturb bat species, which are known to avoid areas of elevated noise while foraging (Schaub et al. 2008).

Alternative 2 may impact individual pale Townsend's big-eared bat and spotted bat, but it is not likely to result in a trend toward federal listing or loss of species viability.

Small Mammals

Gunnison's prairie dog, American marten, Goat Peak pika, American pika, and cinereus shrew may be affected by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres may be disturbed within potential small mammal habitat in the project area and may reduce the

[10] Appearing or active during the day
[11] Appearing or active in twilight

number of acres of suitable habitat available. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. Geothermal development would have the greatest impact on small mammals if it were to affect specialty habitats, such as riparian areas, wetlands, alpine talus, caves, or wintering and breeding areas. NSO stipulations would apply to several specialty habitats, such as riparian areas, wetlands, and slopes in excess of 40 percent.

The direct injury and mortality of small mammals may occur as a result of geothermal development associated with the RFDS. Equipment used for clearing vegetation and roadways, well pads, and facility sites and vehicles used during operation and closeout would affect special status wildlife that are not mobile enough to avoid them. Of the small mammal species with habitat in the project area, Gunnison's prairie dog and cinereus shrew would be most susceptible. American pika and Goat Peak pika have habitat in high elevation alpine talus, where geothermal development is unlikely.

Noise from geothermal activities can have impacts on small mammals. Principal sources of noise are trucks, drilling rigs, and heavy machinery. The most impacts associated with noise could occur if critical life cycle activities, such as mating, were disrupted. All small mammals could be disturbed by noise. Disturbance during mating or rearing of young can cause wildlife to abandon mating activities and can strand young, leaving them susceptible to predation and starvation.

Alternative 2 may impact individual Gunnison's prairie dog, American marten, Goat Peak pika, American pika, and cinereus shrew, but it is not likely to result in a trend toward federal listing or loss of species viability.

Plants

Yellow lady's slipper, Heil's alpine whitlowgrass, woodlily, Santa Fe blazingstar, and Arizona willow may be impacted by habitat alteration, removal, reduction, or fragmentation. Up to 674 acres may be disturbed in potential sensitive plant habitat in the project area, and acres of suitable habitat available may be reduced. Habitat at drilling pads, facilities, roadways, and transmission corridors may be affected. The magnitude of the disturbance would be a function of the level of preexisting disturbance and the size, scale, and phase of geothermal development.

Fragmentation can separate sensitive plant populations into smaller populations, making them more vulnerable to drought, surface disturbance, and disease. Fragmentation can facilitate the spread and introduction of invasive plant species. Roads and other corridors can facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement of wild or human vectors (Trombulak and Frissell 2000). Sensitive plants can be affected by invasive vegetation through competition for resources and available habitat. However, BMPs for noxious weeds identified in Appendix C, including development of a weed control plan and use of a controlled inspection and cleaning for construction equipment, would reduce the potential for noxious weed invasion. Wildfire could remove acres of suitable habitat for special status plants and could reduce the quality of remaining habitat.

The direct removal and mortality of sensitive plants would likely not occur as a result of geothermal development associated with the RFDS. Before geothermal activity begins, BMPs such as clearance surveys could be incorporated as appropriate into permit applications, or included in the approved use authorizations. These measures would allow for detection and avoidance of sensitive plant populations prior to disturbance. NSO stipulations for riparian areas and wetlands would reduce the potential to impact yellow lady's slipper, woodlily, and Arizona willow.

Alternative 2 may impact individual yellow lady's slipper, Heil's alpine whitlowgrass, woodlily, Santa Fe blazingstar, and Arizona willow, but it is not likely to result in a trend toward federal listing or loss of species viability.

3.13.2.6 Impacts Under Alternative 3

There would be no lands available for leasing in the project area under Alternative 3. There would be no direct or indirect impacts on threatened, endangered, and sensitive species from geothermal activities under Alternative 3.

3.13.2.7 Impacts Under Alternative 4

Direct and indirect impacts on federally listed species, raptors and migratory birds, bats, small mammals, and plants would be the same as those described under Alternative 2; however, the level of intensity of disturbance could be more severe under Alternative 4 for fish, aquatic communities, and other species that use or depend on riparian environments. This is because the NSO stipulations under Alternative 2 are more restrictive for intermittent streams and soils with severe erosion potential.

Intermittent streams, along with a 500-foot protection zone, are subject to NSO stipulations under Alternative 2, compared to CSU stipulations under Alternative 4. The potential disturbance on intermittent streams could lead to increased sedimentation flowing into perennial streams and could have an impact on species that are sediment intolerant, such as Rio Grande sucker, Rio Grande chub, RGCT, and other cold water fish species.

3.13.2.8 Cumulative Impacts

The cumulative impacts analysis region of influence for threatened and endangered species and special status species is the three level 4 watersheds that intersect the project area: the Rio Grande-Santa Fe, Rio Chama, and Jemez watersheds. Impacts on threatened, endangered, and sensitive species do not end at the project area boundary but would encompass migration corridors, large home ranges, and cross-boundary landscapes that extend beyond SFNF land.

Past, present, and reasonably foreseeable future actions are discussed in **Section 3.3.4**. The following projects would increase the amount of disturbance in the cumulative impacts analysis area:

- Pueblo of Jemez Red Rocks Dam Repair
- Abiquiu Land Grant Waterline Replacement
- McKinney County Dam
- Mineral development in the South Pit Pumice Mine Expansion and the Duran 2010 Pumice Mine

Projects that should improve habitat conditions in the cumulative impacts analysis area are as follows:

- Southwest Jemez Mountains Restoration Project,
- Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project
- Pueblo of Jemez Owl Springs Bridge Sediment Removal Project

- New Mexico Meadow Jumping Mouse Critical Habitat Projection Project
- Supplement to the Final EIS for Invasive Plant Control Project

The response of individual species to past, present, and reasonably foreseeable future actions would vary, depending on the life history and habitat needs of the species. However, in general, projects that increase the amount of disturbance could reduce habitat or cover where those projects occur.

Alternatives 1, 2, and 4 would increase the number of acres of disturbance in the cumulative impacts analysis area, when combined with other past, present, and reasonably foreseeable future actions. An expanded road network within the project area could increase fragmentation and reduce the habitat quality for special status species in the cumulative impact analysis area. However, NSO, CSU, and TL stipulations under Alternatives 2 and 4 would limit wildlife impacts in seasonally important habitats (such as goshawk PFAs, peregrine falcon eyrie nesting areas, and MSO PACs), designated or proposed critical habitats, and riparian areas.

For fish and other aquatic special status species, stipulations for rivers, streams, and erosive soils under Alternatives 2 and 4 would restrict geothermal development in these areas, thereby maintaining acres of occupied and potentially suitable habitat.

Geothermal development, in combination with other surface-disturbing projects or wildfire, could reduce the number of acres of potentially suitable habitat for special status wildlife and plants in the cumulative impacts analysis area; however, clearance surveys would be required in advance of surface-disturbing geothermal activities.

Combined with other reasonably foreseeable future actions, no significant cumulative impacts on threatened, endangered, and sensitive species or their habitat is expected from Alternatives 1, 2, and 4. Alternative 3 would have no cumulative impacts on threatened, endangered, and sensitive species or their habitat.

3.14 Livestock Grazing

3.14.1 Affected Environment

The primary law governing grazing on NFS lands is the Public Rangelands Improvement Act of 1978. The three enabling statutes that govern grazing on NFS lands are the Organic Administration Act, the Bankhead-Jones Farm Tenant Act, and the Multiple-Use Sustained-Yield Act.

The Forest Service primarily manages grazing and management on NFS lands under 36 CFR, Part 222, Forest Service Manual 2200 – Range Management, and Forest Service Handbook 2200 – Range Management (Forest Service 2016f). Under this management, ranchers may obtain a grazing permit for an allotment of public or NFS land on which a specified number of livestock may graze. An allotment is an area of land designated and managed for livestock grazing. The number of permitted livestock on a particular allotment on public land is determined by how many animal unit months[12] (AUMs) that land will support. Upper and special limits governing the total number of livestock for which a person is entitled to hold a grazing permit on NFS lands is determined by the Chief of the Forest Service (36 CFR, Part 222).

[12] The quantity of forage required by one mature cow and her calf (or the equivalent in sheep or horses) for one month.

There are 17 grazing allotments on NFS lands in the SFNF Geothermal Decision Area (see **Figure 3-2**). **Table 3-16**, below, outlines the active grazing allotments that occur in the SFNF Geothermal Decision Area, as well as the total acres and AUMs designated for each.

Table 3-16. Livestock Grazing Allotments in the Santa Fe National Forest Geothermal Decision Area

Allotment Name	Acres in the Decision Area[1]	AUMs
Alamo	5,100	332
Bland Canyon	100	15
Cebolla/San Antonio	19,700	1544
Chicoma	3,800	152
Coyote	19,900	2457
Del Norte	4,900	337
Jarosa	8,200	3022
Las Conchas	1,400	337
Mesa Del Medio	14,200	1085
Penas Negras	3,800	1387
Peralta	3,700	267
Polvadera	4,800	186
Recreation	3,500	0
San Diego	17,200	2522
Vallecitos	15,800	671
V-Double Slash	12,400	1908
Youngsville	30,300	5640

Sources[13]: Forest Service GIS 2015
[1]Rounded to the nearest 100

3.14.2 Environmental Consequences

3.14.2.1 Scoping Comments on Resource

The following issue specific to livestock grazing was identified during the public scoping period:

- How would geothermal leasing affect grazing allotments and grazing forage?

3.14.2.2 How Resource Impacts Were Evaluated

Method

The method used to determine potential impacts on livestock grazing included a review of available allotment information and GIS data for the geothermal decision area.

[13] Mathew Chavez and Anne Bishop, Forest Service, personal communication with Holly Prohaska, EMPSi. March 2, 2016.

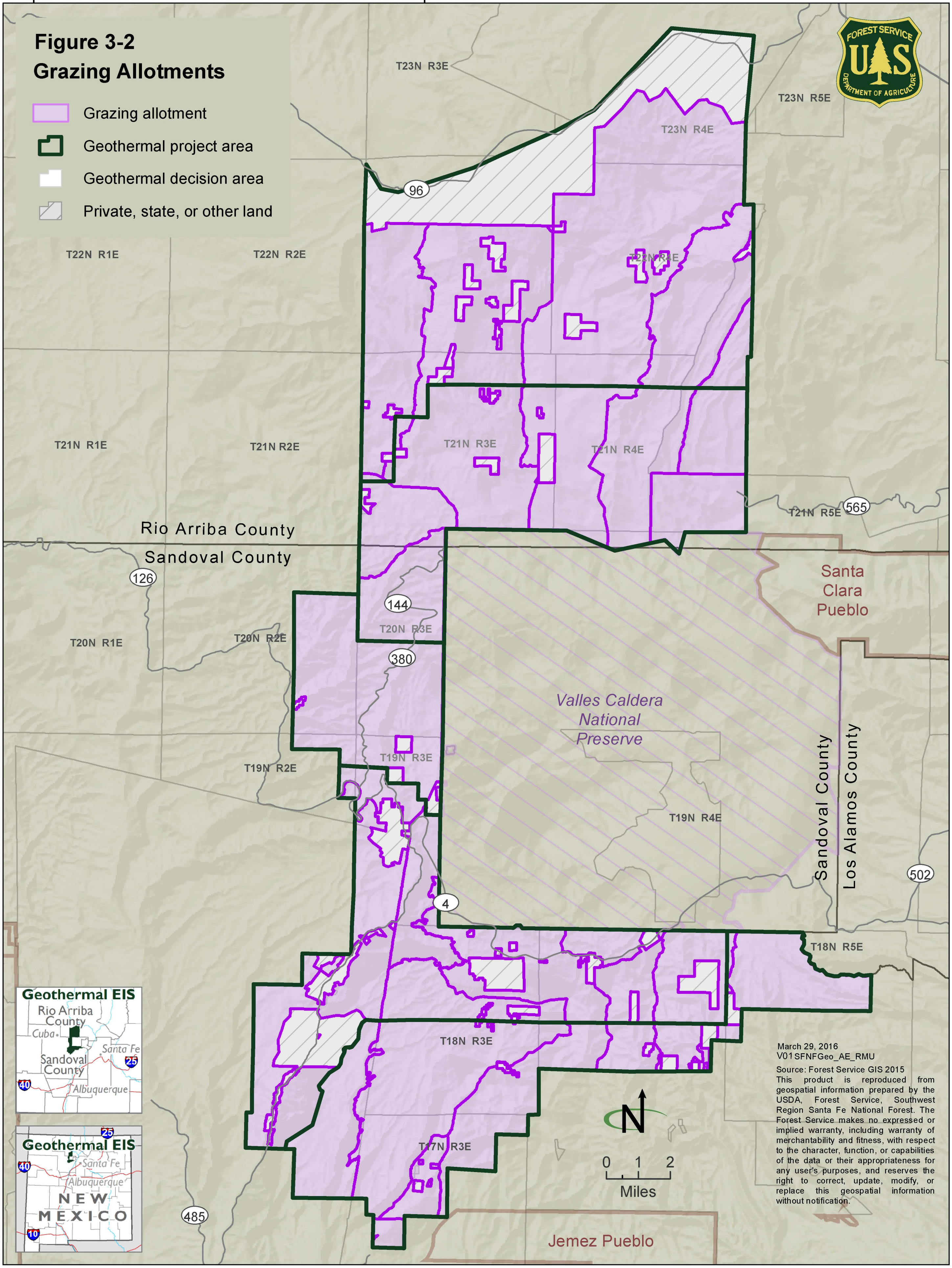
Figure 3-2
Grazing Allotments
Grazing allotment
Geothermal project area
Geothermal decision area
Private, state, or other land
T23N R3E
T23N R4E
T23N R5E
T22N R1E
T22N R2E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
Rio Arriba County
Sandoval County
Santa Clara Pueblo
T20N R1E
T20N R2E
T20N R3E
Valles Caldera National Preserve
T19N R2E
T19N R3E
T19N R4E
Sandoval County
Los Alamos County
T18N R5E
T18N R3E
T17N R3E
Jemez Pueblo
96
126
144
380
4
565
502
485
0 1 2
Miles
March 29, 2016
V01SFNFGeo_AE_RMU
Source: Forest Service GIS 2015
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Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO

Indicators

Potential impacts on livestock grazing could occur if reasonably foreseeable future actions were to result in the following:

- Decrease acreages available to grazing
- Decrease AUM number or forage
- Cause harassment or death of livestock

3.14.2.3 Common Impacts Associated with Geothermal Development

Issuing a geothermal lease does not involve ground-disturbing activities or any type of construction, so there would be no direct impact on livestock grazing. Impacts would result from activities pursued after leasing. Due to the inability to predict the location, scope, scale, and timing of future development, the following impact analysis provides a general description of common impacts on livestock grazing from geothermal resource development.

A detailed description of geothermal development operations relative to livestock grazing resources are described in detail in the 2008 Geothermal PEIS; the phases of geothermal development, including exploration, drilling operations, utilization, and reclamation and abandonment, are also discussed in detailed in the PEIS. Indirect impacts on livestock grazing from the future phases of geothermal exploration or development would occur from ground disturbance on allotments in a lease area. Indirect impacts are temporary or permanent reduction in forage and AUMs, harassment of livestock, shifts in grazing distribution, or changes in season of use.

3.14.2.4 Impacts Under Alternative 1

Under Alternative 1, the JNRA (approximately 28,900 acres) is excluded from geothermal leasing on the basis of existing laws, regulations (43 CFR, Subpart 3201.11), and executive orders. Within those 28,900 acres there would be no disturbance to livestock or livestock management on the allotments in the JNRA from geothermal development (see **Table 3-17**, below). Indirect impacts identified above and in the 2008 geothermal PEIS could occur on allotments outside of the JNRA on a case-by-case basis.

Table 3-17. Livestock Grazing Allotments in the Jemez National Recreation Area

Allotment Name	Acres in the Jemez National Recreation Area	Percentage of Allotment
Cebolla San Antonio	1,600	8
Del Norte	3,300	67
Las Conchas	1,400	100
Peralta	2,100	57
Recreation	3,400	97
San Diego	7,500	44
Vallecitos	3,800	24
V-Double Slash	5,700	46
Total	**28,900**	

Source: Forest Service GIS 2015

Based on the RFDS for the decision area and an estimated disturbance of 27 acres from exploration or 647 acres of development, there is potential for indirect impacts on grazing allotments outside of the JNRA and other closure areas. These impacts would be a reduction in forage, possible reductions in AUMs, and harassment of livestock. However, because the size and location of each geothermal project is not known, the disturbance of approximately 674 acres could be spread across all of the grazing allotments, minimizing overall impacts per allotment.

3.14.2.5 Impacts Under Alternative 2

In addition to portions of allotments closed to geothermal development that fall within the JNRA, Alternative 2 closes other areas based on special circumstances. As such, the Cebollo San Antonio allotment would have an additional 2,600 acres closed to geothermal development, the Vallecitos and V-Double Slash allotments would have an additional 100 acres closed to geothermal development, and the Youngsville would have 300 acres closed to geothermal development. The closures, along with the addition of NSO stipulations, would slightly decrease disturbance of livestock grazing and livestock forage over Alternative 1.

3.14.2.6 Impacts Under Alternative 3

Under Alternative 3, all 194,900 acres of grazing allotments in the project area would be closed to leasing. Therefore, there would be no direct or indirect impacts on livestock or livestock operations from geothermal leasing and development.

3.14.2.7 Impacts Under Alternative 4

Indirect impacts under Alternative 4 would be the same as those described for the No Action Alternative; however, CSU stipulations may decrease harassment of livestock or disturbance of forage where these area overlap.

3.14.2.8 Cumulative Impacts

Cumulative impacts on livestock grazing would occur from the loss of forage for grazing, loss of AUM capacity, and the disruption of livestock grazing practices where geothermal development and other projects create disturbance on grazing allotments in and next to the project area. Past, present, and reasonably foreseeable future actions are discussed in **Section 3.3.4** and include the following projects, which would increase the amount of disturbance in the project area:

- Pueblo of Jemez Red Rocks Dam Repair
- Abiquiu Land Grant Waterline Replacement
- McKinney County Dam
- Mineral development in the South Pit Pumice Mine Expansion and the Duran 2010 Pumice Mine

However, cumulative projects that would also promote healthy forage and clean water in the project area are as follows:

- Southwest Jemez Mountains Restoration Project
- Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project
- Pueblo of Jemez Owl Springs Bridge Sediment Removal Project

- New Mexico Meadow Jumping Mouse Critical Habitat Projection Project (while this project would promote clean water, forage would be protected for jumping mouse habitat and not available to livestock)
- Supplement to the Final EIS for Invasive Plant Control Project

3.15 Cultural Resources

Cultural resources are the present expressions of human culture and the physical remains of past activities, such as buildings, structures, districts, landscapes, archaeological sites, and objects. They can also include locations that can be significant in national, regional, or local history, architecture, archaeology, engineering, or culture. They include sacred sites and natural features significant to contemporary communities or peoples. **Section 3.16** provides an additional discussion of ethnographic resources and the potential for impacts on these resources.

The Cultural Resource Specialist Report (PaleoWest 2016) is incorporated by reference. See the report for a detailed cultural history of the project area and information on regulatory background, data sources, methods, assumptions, and data limitations.

3.15.1 Affected Environment

NEPA requires a consideration of “important historic, cultural, and natural aspects of our natural heritage.” This includes the necessity of independent compliance with the applicable procedures and requirements of other federal and state laws, regulations, and executive orders. The principal federal law addressing cultural resources is the National Historic Preservation Act (NHPA) of 1966, as amended (54 USC, Section 300101 et seq.) and its implementing regulations found at 36 CFR, Part 800.3. These regulations, commonly referred to as the Section 106 process, describe the procedures for identifying and evaluating historic properties, for assessing the impacts of federal actions on historic properties, and for project proponents consulting with appropriate agencies to avoid, reduce, or minimize adverse impacts. Historic properties are cultural resources that meet specific criteria for listing on the NRHP.

Among other mandates, Section 110a of the NHPA (54 USC, Sections 306101[a] and 306102) requires federal agencies to develop a program that ensures that historic properties under the jurisdiction or control of the agency are identified, evaluated, and nominated to the NRHP. It also requires that they be maintained in a way that considers the preservation of their historic, archaeological, architectural, and cultural values. Although leasing consent has no direct impact on cultural resources, it is a commitment of resources that may result in potential impacts in the future. Thus, in support of this EIS, the Forest Service has prepared a cultural resource specialist report examining the entire geothermal potential area, rather than simply considering reasonably foreseeable development or past lease interest areas. The goal of the report is to compile information on previously recorded cultural resources and cultural resource inventories in the project area. Cultural resource GIS data for sites and projects provided by the Forest Service is current and accurate as of fall 2015 (PaleoWest 2016).

3.15.1.1 Inventory

Archaeologists have surveyed approximately 102,002 acres, or 52 percent, of the project area, including all levels of pedestrian survey on SFNF, private, and state lands. Many previous surveys are overlapping, and therefore cultural resource surveys have covered 233,643 acres in 965 survey projects. Most of the higher density of survey coverage is in the central and southern portion of the project area. Based on reported field methods, inventories are categorized as valid and complete (consistent with current Forest Service standards), less than complete, or unknown by the Forest Service. These assessments of survey validity are not absolute but are considered when determining cultural resource identification for specific undertakings. Valid and complete survey coverage is estimated at approximately 28 percent of the project area, or 54,558 acres.

The Forest Service has identified 1,962 cultural resource sites on the 102,002 surveyed acres in the project area. These consist of a wide variety of prehistoric and historic era resources.

Human occupation of the Jemez Mountains spans from the earliest identified culture in the United States (Paleo-Indian) to the present. Most cultural resource sites identified in the project area are prehistoric (1,054, or 54 percent); 143 sites (7 percent) are historic; 368 sites (19 percent) have both prehistoric and historic components; 388 sites (20 percent) are unknown; and the cultural affiliation of 9 sites (less than 1 percent) was not reported. Eight sites are linear, such as roads and trails.

Contemporary pueblo, tribal, and Hispanic groups have traditional ties to ancestral sites, landscapes, and resources in the project area. These are not necessarily enumerated or recorded in these inventories, but they are of concern from a cultural resource management perspective. The Forest Service is responsible for considering the impacts of its actions on traditional cultural properties and traditional cultural practices. **Section 3.16** provides additional discussion of ethnographic resources and the potential for impacts on these resources.

Prehistoric resources are field houses, agricultural terraces, grid gardens, pueblo villages, roomblocks, pithouses, rock art panels, rock shelters, rubble mounds/habitations, campsites, activity areas, hearths, hunting features, storage features, cairns, shrines, trails, lithic quarries, lithic and pottery scatters, and burials. Historic era resources are ranching and livestock sites, railroad and logging sites, cabins ruins, refuse scatters and roads, and erosion control features.

More than half of the sites in the project area (1,152) are situated between 7,000 and 8,000 feet above mean sea level. One site occurs at an elevation of less than 6,000 feet, 201 sites are between 6,000 and 7,000 feet, 494 sites are between 8,000 and 9,000 feet, and 113 sites are at elevations over 9,000 feet. Only 11 sites have been located above 10,000 feet in elevation.

The GIS data included 405 site records where NRHP eligibility was reported. Eligibility recommendations of 1,557 sites were not reported and should be treated as “unevaluated.” Of the sites with eligibility recommendations, 6 are listed on the NRHP, 288 are recommended as eligible for listing, 21 are ineligible for listing, and 90 are unevaluated (PaleoWest 2016).

Six properties in the project area are listed on the NRHP: one in the JNRA (LA56557 [Virgin Logging Camp #2]) and five in the southern part of the project area (LA303 [Sayshukua], LA475 [Totaskwina], LA478 [Wabakwa], LA386, and LA5920). LA675, known as Gíusewa Pueblo (Jemez State Monument), is listed on the NRHP and is National Historic Landmark #12001007. Gíusewa is in the project area but is on land owned by the State of New Mexico.

All of the above sites, aside from the logging camp (LA56557), were listed under a National Register Multiple Property nomination, Jemez Cultural Developments in North-Central New Mexico (NPS 1990).

3.15.2 Environmental Consequences

3.15.2.1 Scoping Comments on Resource

The following issues specific to cultural resources were identified during the public scoping period:

- How would cultural resources be affected by geothermal leasing?
- How would these impacts be managed?

3.15.2.2 How Resource Impacts Were Evaluated

A consent to leasing and leasing decisions do not grant any rights or authorize any activities affecting cultural resources. The impact analysis focuses on the potential future actions and disturbance estimates, based on the RFDS, and the implementation of the alternatives described in **Chapter 2**. In all cases, before any ground disturbance or other future actions, further decision-making would be required, including cultural resource compliance.

Methods

PaleoWest (2016) reviewed cultural resource baseline information for an understanding of known resources and to determine the condition of the resources. Also, it considered all laws pertinent to determining the impacts on cultural resources and included them in criteria for determining impacts. Known resources and an informed estimation of site density in unsurveyed areas was overlain with the actions found under each alternative in **Chapter 2**. Conclusions were drawn, based on an understanding of how these types of actions may affect the known and potentially discoverable resources (PaleoWest 2016).

Based on ongoing consultation with contemporary pueblo, tribal, and Hispanic groups, the SFNF used a qualitative assessment of the potential for impacts on sites, landscapes, and other resources that may be important to those groups for traditional or religious uses (Forest Service 2016g).

Indicators

Potential impacts on cultural resources could occur if anticipated future actions, consistent with implementing the alternatives described in **Chapter 2**, were to have any of the following impacts:

- Conflict with Forest Service goals and objectives to inventory, protect, evaluate, nominate to the NRHP, interpret, and enhance cultural resources
- Result in uses that are incompatible or that interfere with maintaining cultural resources and their qualities or traditional cultural properties, practices, and uses
- Result in an adverse impact on historic properties under Section 106 of the NHPA

Impacts on cultural resources occur when there is damage or loss of cultural resources or their settings. Impacts on cultural resources are assessed by applying the NHPA criteria of adverse impact, as defined in the implementing regulations for Section 106 of the NHPA (36 CFR, Part 800).

An adverse impact is found when an action may alter the characteristics of a historic property that qualify it for inclusion on the NRHP, in a manner that would diminish the integrity of the property’s location, design, setting, workmanship, feeling, or association. Adverse impacts may include reasonably foreseeable impacts caused by the action that may occur later in time, be farther removed in distance, or be cumulative (36 CFR, Subpart 800.5).

Additionally, focused consultation with the affected group is required to assess impacts involving contemporary pueblo, tribal, or other traditional community's cultural or religious practices, resources, or areas. Impact analysis would be informed by ongoing consultation with groups with interests in the SFNF and focused consultation for subsequent actions and decisions (Forest Service 2016g).

For the purposes of this analysis, indicators for determining impacts on cultural resources are to ask if the action would have any of the following impacts:

- Cause physical destruction or damage to all or part of the property
- Alter a property in a manner that is not consistent with the Secretary of the Interior's standards for the treatment of historic properties (36 CFR, Part 68) and applicable guidelines
- Remove the property from its historic location
- Change the character of the property's use or physical features in its setting that contribute to its historic significance, such as isolating the property from its setting
- Introduce visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features
- Neglect a property, which causes its deterioration, except where such neglect and deterioration are recognized qualities of a property of religious and cultural significance to an Indian tribe
- Disturb any human remains, including those interred outside of formal cemeteries

Under the NHPA, any of the above indicators would contribute to an adverse impact on a cultural resource if it were listed on or eligible for listing on the NRHP, or if it were an area of importance to Native American tribes, pueblos, or other traditional communities.

Impacts can be direct or indirect. In practice, a direct impact would be limited to the direct physical disturbance of a historic property, such as destroying the property for facility or access construction. Indirect impacts would be visual or audible intrusion as a result of the project being built or the increased risk of looting as a result of better access and increased visitation to the area.

Impacts on cultural resources are typically considered permanent, as they are finite, and any disturbance, particularly of archaeological sites, cannot be reversed. However, impacts on the historic landscape or the viewsheds of historic or other culturally significant areas can be temporary, if projects do not permanently impact associated resources and are removed at a future date.

Adverse impacts can be resolved or reduced through avoidance and other measures that the applicant would implement, in coordination with the Forest Service and the BLM.

Assumptions

This analysis assumes the following:

- There would be no findings of adverse impact from any of the alternatives, because consent to leasing would not disturb the ground. Future geothermal development phases would be subject to additional analyses under NEPA and the NHPA, and adverse impacts from such actions would be identified at that time.

- Cultural resource protection and avoidance measures apply to all proposed federal or federally assisted undertakings by the Forest Service and to leases granted by the BLM.
- Several decision stages would occur before any ground-disturbing activities and would include further compliance with applicable authorities. If leasing were approved, the Forest Service and the BLM would complete steps to meet cultural resource legal and procedural requirements before development begins, as outlined in the Section 106 process and the Region 3 Programmatic Agreement (Forest Service 2003). These include consultation with the New Mexico State Historic Preservation Office (SHPO) and Native American tribes, pueblos, or other traditional communities.
- The number of sites that could be affected by actions correlates with the degree, nature, depth, and quantity of surface-disturbing activities in the project area and the cultural sensitivity of the area.
- The information on cultural resources in the project area is based on the results of industry and Forest Service inventory projects and depicts the relative potential for cultural resource sites. However, these data are geographically biased toward past project-oriented undertakings and cannot accurately predict where and how many resources may exist in unsurveyed areas.
- Likewise the presence and significance of sites, landscapes, and other resources that may be important to contemporary pueblo, tribal, and Hispanic groups for traditional or religious uses may not be readily identifiable outside of those communities.
- Cultural resource inventories, either federal undertakings or related programs, would result in the continued identification of cultural resources. The cultural resource data acquired through these inventories and evaluations would increase overall knowledge and understanding of the distribution of cultural resources in the region.

3.15.2.3 Common Impacts Associated with Geothermal Development

The nature and characteristics of the direct and indirect impacts on cultural resources from geothermal development under the decisions common to Alternatives 2, 3, and 4 would be the same as those described in the 2008 Geothermal PEIS (BLM and Forest Service 2008, pp. 4-106 to 4-108) is incorporated by reference and summarized here. The PEIS describes common impacts on cultural resources associated with exploration, drilling, utilization, reclamation, and abandonment.

Any activities that would involve surface-disturbing activities would have direct and indirect impacts on cultural resources, including damaging, destroying, or displacing artifacts and features and building modern features out of character with a historic setting. Damaging, displacing, or destroying cultural resources could include removing artifacts from their situational context, breaking artifacts, or shifting, obliterating, or excavating features without appropriately recording them.

Indirect impacts on cultural resources would include changing the character of a property's use or physical features in its setting that contribute to its historic significance (such as isolating the property from its setting) and introducing visual, atmospheric, or audible elements that diminish the integrity of its historic features. The geothermal plants, well pads, and associated facilities would be modern features in a landscape that did not have them previously, thereby juxtaposing modern industrial features onto a historic landscape. Additionally, with the increased human presence of site workers during all phases of geothermal development, there is the risk of illicit collection of surface artifacts, resulting in a loss of scientific information.

The potential for undiscovered buried cultural resources and human remains exists, despite previous archaeological surveys and investigations. Surface-disturbing activities would directly impact undiscovered cultural resources and human remains by exposing buried material, resulting in inadvertent artifact destruction or loss of scientific context. Indirect impacts could result from the increased presence of site workers, leading to possible illicit collection of newly exposed materials.

Final reclamation of geothermal developments would eliminate the indirect viewshed or setting impacts for cultural resources. With reclamation, the natural and historic setting would be restored. Similar to impacts during earlier phases, the potential for undiscovered buried cultural materials or human remains continues to exist through reclamation and abandonment. Abandonment may expose buried materials, resulting in inadvertent artifact destruction or loss of scientific context; additionally, the increased presence of site employees may lead to illicit collection of exposed materials.

3.15.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. The level of anticipated geothermal leasing and development is assumed to be consistent with the RFDS. If geothermal lease applications and nominations are received, they would be processed and evaluated on a case-by-case basis under separate NEPA and NHPA analyses, in accordance with the Forest Plan and existing laws and regulations. Potential direct and indirect impacts from subsequent geothermal development phases would be the same as those described for *Common Impacts Associated with Geothermal Development.*

Because there would be site-specific analysis, potential impacts on cultural resources and their settings could be avoided or reduced, but there would be no additional established stipulations for surface use that may incidentally reduce impact potential on cultural resources. The JNRA is excluded from geothermal leasing on the basis of existing laws, regulations, and executive orders. There would continue to be no leasing in the JNRA and thus no impacts on cultural resources from subsequent geothermal development phases.

3.15.2.5 Impacts Under Alternative 2

Under Alternative 2, the SFNF would identify lands as being closed to geothermal leasing under either nondiscretionary or discretionary authorities, or open to geothermal leasing, with TL, CSU, and NSO stipulations. Compared with Alternative 1, Alternative 2 provides standard stipulations and consideration for resource protection and other uses for the project area for geothermal leasing, consistent with forest goals and objectives. There would still be site-specific consideration of impacts on cultural resources and their settings for each phase of geothermal development.

Alternative 2 includes NSO stipulations for areas with important cultural resources and their settings, including archaeological resources, traditional cultural properties, sacred sites, and NRHP-eligible and listed properties. Because of this, the potential for impact on cultural resources from subsequent geothermal development would be reduced. Additional established stipulations for other surface uses may incidentally reduce the impact potential on cultural resources. There are 1,567 known sites that would be included in land with NSO stipulations under Alternative 2.

3.15.2.6 Impacts Under Alternative 3

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. Because there would be no leasing and no subsequent development, there would be no impacts on cultural resources and their settings.

3.15.2.7 Impacts Under Alternative 4

Under Alternative 4, the SFNF would not identify lands as being closed to geothermal leasing under discretionary authorities. Lands would be identified as open to geothermal leasing with TL, CSU, and NSO stipulations. Compared with Alternative 1, Alternative 4 provides standard stipulations and consideration for resource protection and other uses for the project area for geothermal leasing, consistent with forest goals and objectives. There would still be site-specific consideration of impacts on cultural resources and their settings for each phase of geothermal development.

Alternative 4 includes NSO stipulations for areas with important cultural resources and their settings, including archaeological resources, traditional cultural properties, sacred sites, NRHP-eligible and listed properties. Because of this, the potential for impacts on cultural resources from geothermal development would be reduced. Additional established stipulations for other surface uses may incidentally reduce the impact potential on cultural resources. There are 1,522 known sites that would be included in land with NSO stipulations under Alternative 4.

3.15.2.8 Cumulative Impacts

Cumulative impacts on cultural resource are analyzed at the landscape scale for the project area. Past, present, and reasonably foreseeable future actions are those that would increase surface disturbance in the project area, potentially affecting cultural resources. These are the following:

- Pueblo of Jemez Red Rocks Dam Repair
- Abiquiu Land Grant Waterline Replacement
- McKinney County Dam
- South Pit Pumice Mine Expansion
- Duran 2010 Pumice Mine
- Southwest Jemez Mountains Restoration Project
- Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project
- Pueblo of Jemez Owl Springs Bridge Sediment Removal Project
- New Mexico Meadow Jumping Mouse Critical Habitat Protection Project

Those that are in the project area have now or will have cultural resource compliance actions through the Section 106 process and the Region 3 Programmatic Agreement. These would seek to avoid or reduce the potential for adverse impacts on cultural resources. The full RFDS under Alternatives 1, 2, and 4 may impact cultural resources and their settings, but impacts would be reduced through the Section 106 process and the stipulations that would be implemented. The contributions to direct cumulative impacts would be minor, relative to the project area, although, depending on siting, the indirect impacts on setting and cultural landscapes may be moderate. There would be no contributions to cumulative impacts under Alternative 3.

3.16 Tribal Interests and Traditional Cultural Resources

Tribal interests include economic rights, such as Indian trust assets, and resource uses and access guaranteed by treaty, agreements, or legislation. Traditional cultural resources include areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas.

As discussed in **Section 3.15**, Cultural Resources, places that are important in maintaining community traditions or culturally important activities can also be recognized as eligible for listing on the NRHP as traditional cultural properties.

While most commonly considered in the context of Native American tribes and pueblos, there are traditional cultural resources associated with other ethnic or socially linked groups in the Jemez Mountains and project area, such as Hispanic land grants and communities. Although the SFNF does not have decision concurrence authority over leasing on Indian reservations, there are tribal and other traditional uses of Forest Service lands that could be impacted from subsequent phases of geothermal exploration, drilling operations, utilization, and reclamation and abandonment. Adjacent or nearby reservation land and land grants may also be impacted by these actions. When planning any proposed project or action, the agencies must ensure that all anticipated impacts on Indian lands, trust resources, and treaty rights are addressed in the planning, decision, and operational documents prepared for each project. Federal agencies must ensure that meaningful consultation and coordination are conducted on a government-to-government basis with federally recognized tribes.

The trust responsibility is the US government's permanent legal obligation to exercise statutory and other legal authorities to protect tribal lands, assets, resources, and treaty rights, as well as a duty to carry out the mandates of federal law with respect to Native American tribes. Treaties are negotiated contracts made pursuant to the US Constitution and take precedence over any conflicting state laws because of the Constitution's supremacy clause (Article 6, Clause 2).

Other sources of defined reciprocal rights and obligations assumed by the federal government and Indian tribes are congressional and executive branch actions to acquire or repatriate Indian lands, establish reservations, provide federal recognition of tribes, and remove Indian peoples to reservations.

Communities often view these rights and resource uses as interconnected with culture, tradition, and spiritual practice. Among many groups, land, water, geologic features, landscapes, and other seemingly inanimate objects are considered sacred. Examples of traditional cultural resources are natural landscape features, ceremonial and worship places, plant gathering locations, traditional hunting and fishing locations, ancestral archaeological sites, artisan material locations, rock art, and communal resources, such as community-maintained irrigation systems.

While many traditional cultural resources are known, many locations or resources may be privileged information that is restricted to specific practitioners or clans. For tribes, maintaining confidentiality and customs regarding traditional knowledge may take precedence over identifying and evaluating these resources, unless they are in imminent danger of damage or destruction.

3.16.1 Affected Environment

3.16.1.1 Overview

Native American occupation and use of the lands of the Jemez Mountains for thousands of years is well documented in the archaeological record and by oral traditions. Patterns of occupation and use changed through time, ranging from small, highly mobile bands following the seasons and resources to small and large permanent and semipermanent communities, defensive sites, and agricultural fields (PaleoWest 2016). During the Spanish contact and early colonization period (1540-1610), the vast majority of puebloan villages were located near the junction of the Rio Grande and Rio Chama, along the Rio Grande, and along the Jemez River. Still, artifacts and faunal and botanical data clearly show that the mountains continued to be visited for hunting, gathering, raw material procurement, and field house-based high altitude farming.

Spanish colonization of New Mexico brought the alien concept of landownership to the pueblo world that was in conflict with native concepts of movement across the land, seasonal lowland-upland migrations, and religious associations with landscape and water features.

From 1609 to 1680, the Spaniards developed New Mexico through a system of religious missions, military presidios, the feudal system of *encomiendas*, and agricultural land grants. In theory, the Spanish Crown issued patents or grants for lands to native communities, which colonial officials were then charged with protecting from adverse activities by Hispano settlers. The problem of settler encroachment on Indian fields, disenfranchisement of native lands, and abuse by colonists was a universal one under Spanish and later Mexican rule. Mexico honored the land grants already established by the Spanish Crown for both pueblo people and Hispanic settlers, but it also created a system for establishing new immigrant settlements of Europeans and Americans who would become Mexican citizens. Those outside influences and new trade through the Santa Fe Trail caused more American occupation of Mexican territory, leading to the US-Mexican War of 1846-1848.

The war ended with the Treaty of Guadalupe Hidalgo. The treaty also affirmed established land grants, but in practice it failed in most cases to protect them. Some land grants have been incorporated into the SFNF. There is a long subsequent history of congressional and Executive Branch actions and litigation regarding land grants, reservation boundaries, sovereignty, and tribal rights that continue to the present (Forest Service 2016g).

3.16.1.2 Resources

The SFNF regularly consults on a government-to-government basis with federally recognized tribes and engages with communities on the impacts of their actions and programs. In support of this EIS and Southwest Jemez Mountains Landscape Restoration Project, the SFNF consulted with descendants of Native American and Hispanic land grant recipients, who had occupied portions of the Jemez Mountains and adjacent areas prehistorically and historically and maintained traditional cultural resources and practices associated with those resources.

The Forest Service contracted an ethnographic overview and assessment of traditional and current land uses by Native American and other communities. The intent is to identify traditional uses across the Jemez Mountains at the landscape level, but not to single out specific locations or traditional cultural resources, unless their significance to landscape-scale planning is appropriate and necessary. A general review of this outreach and results is provided in a public summary (Forest Service 2016g).

The SFNF determined the following Native American communities could be directly affected by future projects either because they are adjacent to Forest lands or have long-term documented intensive use of the Jemez Mountains: Pueblo of Jemez, Pueblo of Zia, Pueblo of Santo Domingo (Kewa), Pueblo of Santa Ana, Pueblo of Cochití, Pueblo of Ohkay Owingeh, Pueblo of Santa Clara, Pueblo de San Ildefonso, Pueblo of Nambé, Pueblo of Pojoaque, Pueblo of Tesuque, Pueblo of San Felipe, Jicarilla Apache Tribe, and the Navajo Nation. It is understood that many other tribes have had associations with the Jemez Mountains, either through inter-tribal relationships or more sporadic occupation of lands or resource use.

Land grants recognized as units of government include the Abiquiu Land Grant and the San Joaquin del Rio de Chama Grant. Land grants incorporated into the SFNF include the Polvadera Grant, Juan Jose Lobato Grant, Ojo de San Jose Grant, Cañon de San Diego Grant, and Baca Location No. 1 Grant. The ethnographic studies, interviews and consultation with these communities broadly identified traditional use areas, significant plant and animal resources, mineral resources, visual resources, and traditional community perspectives on direct and indirect impacts of geothermal leasing and landscape restoration on those resources.

Ongoing consultation with representatives of pueblo and tribal groups indicated that the Jemez Mountains are important as a sacred place, as a sacred landscape, or as a historic landscape. Within the Jemez Mountains are subregions (based primarily on topography) that were discussed regarding specific concerns. Many landforms and locations have defined place names and are described in the oral traditions of the pueblo and Hispanic people. Areas of concern relate to high peaks that may contain shrines and campsites near the shrines, trails for access and ceremonies that extend variously through the Jemez Mountains or within these sub-regions, high areas, such as alpine meadows for plant collecting, ancestral sites and cultural resources, and springs that provide water for ceremonies, consumption, and supply water for grazing allotments and farming. General areas of concern as traditional use areas are known, but specific locations of traditional cultural resources, plant gathering areas, and other important locations are not revealed.

Continued forest management practices were encouraged to attain healthy, stable forest environments, but practices should include sensitive consideration of the cultural heritage associations and traditional uses of the areas by those who were consulted and those who choose to not discuss their particular interests or resources. Groups fear that geothermal energy development will have devastating impacts on the area, including impacting the availability of water resources and the quality of water and effects on other resources that are important for their heritage and ceremonies.

In general, the representatives of the groups interviewed were not in favor of geothermal energy development, or they expressed concerns about the impacts on water quality and availability. Native American and Hispanic groups are also interested in recovering ownership of lands that were part of their original land base and, therefore, would be concerned about committing lands to other uses.

The All Pueblos Council of Governors adopted a resolution on August 10, 2015, unanimously supporting closing the forest to geothermal leasing. The resolution called on the SFNF to restrict all access in the Jemez Mountains and Santa Fe National Forest to proposals from the geothermal and energy and minerals industry and expressed the Council’s support for the designation of the Jemez Mountains as a traditional cultural property. The resolution requests that meetings be held to inform and consult with pueblo leadership regarding this proposal (All Pueblo Council of Governors 2015).

3.16.2 Environmental Consequences

3.16.2.1 Scoping Comments on Resource

The following issues specific to tribal interests and traditional cultural resources were identified during the public scoping period:

- How would traditional cultural properties and tribal interests be affected by geothermal leasing, including those in confidential locations, and how would those impacts be managed? What are the direct, indirect, and cumulative impacts of other resource impacts on tribal interests?

Method

Consent to leasing and leasing decisions do not grant any rights or authorize any activities that would directly affect tribal interests and traditional cultural resources. However, issuing geothermal leases confers on the lessee a right to future exploration and development of geothermal resources in the lease area. Thus, it is a conditional commitment or granting of a right that may interfere with other uses or interests, such as land-into-trust applications by tribes or acquisition of ancestral land base or resources.

The impact analysis focuses on the potential future actions and potential for direct impacts or disturbances, based on the RFDS and the implementation of the alternatives described in Chapter 2. In all cases, before any ground disturbance or other future actions, further decision-making would be required. Examples are NEPA, NHPA compliance, and meaningful consultation and coordination with affected communities, on a government-to-government basis, with federally recognized tribes and pueblos.

As described above, the SFNF regularly consults with Native American groups and other traditional communities on its activities and is conducting a landscape-scale study of past and present uses of the Jemez Mountains in support of this EIS and other actions. This work for each of the tribal groups and land grants includes ethnographic archival research and interviews to define and provide a more holistic understanding of tribal interests and the range and variety of traditional cultural resources and uses of the Jemez Mountains. The identification is at an appropriate level for determining the impacts of leasing consent. Laws, regulations, and policies pertinent to determining impacts on tribal interests and resources were considered and included in the impact criteria.

A qualitative assessment is used to assess the potential for impacts on sites, landscapes, and other resources that may be important to contemporary pueblo, tribal, and Hispanic groups for traditional or religious uses, based on ongoing consultation with these groups. Locally sensitive areas and resources may be known from previous consultation and resource identification efforts. However, affected groups may not wish to enter into direct consultation or may prefer not to discuss specific traditional use areas or sacred sites until development plans are proposed and there is a perception that interests or resources would be threatened.

Indicators

Potential impacts on tribal interests or traditional and heritage resources could occur if anticipated future actions consistent with implementing the alternatives were to result in the following:

- Conflict with land uses, management, and economic well being of adjacent or nearby reservations, trust lands, restricted Indian allotments, and tribal-dependent Indian communities
- Conflict with the exercising of off-reservation treaty and reserved rights and agreements, including grazing rights, hunting and fishing rights, gathering rights and interests, and water rights
- Conflict with federal trust responsibilities to tribes and pueblos regarding real property, physical assets, or intangible property rights
- Conflict with existing court decisions, laws, policies, executive orders, and agency agreements with tribes and land grant communities regarding land and resource use
- Result in proposed uses that are incompatible with maintaining and identifying cultural resources and their qualities
- Have an adverse impact on traditional cultural properties and cultural landscapes under Section 106 of the NHPA (36 CFR, Part 800)
- Impact or restrict access to traditionally used hunting, fishing, and gathering areas and species
- Change or reduce access to traditionally used or culturally important water sources and hot springs
- Impact culturally important trails or trail systems
- Impact sacred sites or their settings, access, or use

Assumptions

This analysis assumes the following:

- Areas proposed for leasing would likely include lands and specific locations where there are tribal interests and traditional cultural resources that are not currently identified.
- The SFNF would continue to coordinate and consult with pueblo, tribal, and affected communities to identify issues and concerns during all phases of geothermal leasing and development.
- Some Native American groups and land grant communities may be interested in recovering ownership of lands or specific resource locations that were part of their original land base and, therefore, would be concerned about committing lands to other uses.
- The Jemez Mountains has been characterized as a sacred place, as a sacred landscape, or as a historic landscape. Disturbing the land or using geothermal resources may be considered an adverse impact that could not be avoided or minimized.
- There may be unidentified conflicts with existing rights or claims of ownership related to hot springs and water sources.

3.16.2.2 Common Impacts Associated with Geothermal Development

The nature and characteristics of the impacts on tribal interests and traditional cultural resources and uses associated with geothermal development as a result of the decisions common to all action alternatives would be the similar to those described in the 2008 Geothermal PEIS (BLM and Forest Service 2008, pp. 4-114 to 4-117). This is incorporated by reference and summarized here.

The PEIS describes common impacts on tribal interests and traditional cultural resources and uses associated with exploration, drilling operations, utilization, and reclamation and abandonment.

Types of impacts that could occur from exploration, drilling operations, utilization, and reclamation and abandonment are direct disturbance of locations or landscapes associated with traditional beliefs, resource gathering areas, hunting and fishing areas, water sources, hot springs, ancestral sites, human remains, and trails. Other impacts could result from alterations of visual and aural aspects of the cultural landscape's setting, both on the lease site and in adjacent areas; increased access and site workers, which could lead to increased incidents of vandalism and unauthorized collection of ancestral sites; decreased tribal member access or interference with the exercise of rights or cultural uses and practices, such as resource gathering or hunting; and the potential for erosion, pollution, habitat loss, and less tangible changes to natural features and resources that tribal members may consider sacred.

Exploration, drilling operations, and utilization in or around hot spring sources may impact traditional resources and could impact other tribal interests. Impacts could include loss of access, interference with use, and changes to hot springs. Since the thermal water in these springs may be considered sacred, there is a potential for loss of sacred sites and the healing energy and power they provide to the tribal users who value them.

While visual and aural settings and some habitats may be restored, it is unlikely that some cultural or sacred uses could be restored.

3.16.2.3 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. The level of anticipated geothermal leasing and development is assumed to be consistent with the RFDS. If geothermal lease applications and nominations are received, they would be processed and evaluated on a case-by-case basis under separate NEPA and NHPA analyses, in accordance with the Forest Plan and existing laws and regulations. Potential direct and indirect impacts from subsequent geothermal development phases would be the same as those described for common impacts associated with geothermal development. Because there would be site-specific analysis and consultation, potential impacts could be avoided or reduced, but there would be no additional established stipulations for surface use that may incidentally reduce impact potential on tribal interests and traditional cultural resources and uses.

Tribes may consider disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. The JNRA is excluded from geothermal leasing on the basis of existing laws, regulations, and executive orders. There would continue to be no leasing in the JNRA and thus no impacts anticipated from subsequent geothermal development phases.

3.16.2.4 Impacts Under Alternative 2

Under Alternative 2, the SFNF would identify lands as being closed to geothermal leasing under either nondiscretionary or discretionary authorities or open to geothermal leasing with TLs and CSU stipulations and NSO stipulations. Compared with Alternative 1, Alternative 2 provides standard stipulations and consideration for resource protection and other uses for the project area for geothermal leasing, consistent with forest goals and objectives. There would be NSO stipulations for traditional cultural properties and Native American sacred sites, as identified through consultation. There would still be site-specific consideration of impacts on tribal interests and traditional cultural resources and uses and their settings for each phase of geothermal development.

Because Alternative 2 includes NSO stipulations for areas with important cultural resources and their settings (archaeological resources, traditional cultural properties, sacred sites, and NRHP-eligible and listed properties), the potential for impact from subsequent geothermal development would be reduced. Tribes may consider disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. Additional established stipulations for other surface uses (i.e., habitat and visual protections) may incidentally reduce the impact potential on traditional cultural resources, cultural landscapes, and their settings.

3.16.2.5 Impacts Under Alternative 3

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. Because there would be no leasing and no subsequent development, no new impacts are anticipated.

3.16.2.6 Impacts Under Alternative 4

Under Alternative 4, the SFNF would not identify lands as being closed to geothermal leasing under discretionary authorities. Lands would be identified as open to geothermal leasing with TLs and CSU stipulations and NSO stipulations. Compared with Alternative 1, Alternative 4 provides standard stipulations and consideration for resource protection and other uses for the project area for geothermal leasing, consistent with forest goals and objectives. There would be NSO stipulations for traditional cultural properties and Native American sacred sites, as identified through consultation. There would still be site-specific consideration of impacts and consultation for each phase of geothermal development.

Alternative 4 includes NSO stipulations for areas with important cultural resources and their settings, including archaeological resources, traditional cultural properties, sacred sites, NRHP-eligible and listed properties. Because of this, the potential for impact on cultural resources from subsequent geothermal development would be reduced. Tribes may consider disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. Additional established stipulations for other surface uses (i.e., habitat and visual protections) may incidentally reduce the impact potential on traditional cultural resources, cultural landscapes, and their settings.

3.16.2.7 Cumulative Impacts

Cumulative impacts on tribal interests and traditional cultural resources and uses are analyzed at the landscape scale for the project area. Past, present, and reasonably foreseeable future actions include those that would increase surface disturbance in the project area, potentially affecting cultural resources. These include Pueblo of Jemez Red Rocks Dam Repair, the Abiquiu Land Grant Waterline Replacement, the McKinney County Dam, South Pit Pumice Mine Expansion, the Duran 2010 Pumice Mine, the Southwest Jemez Mountains Restoration Project, the Cerro Pelon Timber Stand and Wildlife Habitat Improvement Project, Pueblo of Jemez Owl Springs Bridge Sediment Removal Project, and the New Mexico Meadow Jumping Mouse Critical Habitat Protection Project.

Each of these that is in the project area has or will have cultural resource compliance actions and site-specific consultation, which would seek to identify tribal interests and traditional cultural resources and avoid or reduce the potential for adverse impacts. Tribes may consider disturbance of the land or use of geothermal resources as an adverse impact that could not be avoided or minimized. The full RFDS under Alternatives 1, 2, and 4 may impact traditional cultural resources and their settings, but impacts would be reduced through the Section 106 process and the stipulations that would be implemented. The contributions to direct cumulative impacts would be minor to major, relative to the project area. This would depend on the perspective of consulting parties on the impacts on tribal interests and traditional cultural resources. There would be no contributions to cumulative impacts from Alternative 3.

3.17 Visual Resources

3.17.1 Affected Environment

The landscape in the decision area is characterized primarily by montane woodlands and meadows, but also includes canyons and rock outcrops in the southwest portion of the decision area near Jemez Springs and surrounding areas. Elevation ranges from about 6,300 feet to 10,000 feet.

The Forest Service manages visual resources according to the Scenery Management System. The Scenery Management System is described in the IRAs report for this project (Forest Service 2016a).

Table 3-18 and **Figure 3-3**, Scenic Integrity, shows the acres of lands in the decision area by each scenic integrity degree.

Table 3-18. Scenic Integrity

Scenic Integrity	Acres
Very High	3,700
High	93,000
Moderate	67,800
Low	3,800
Very Low	300

Source: Forest Service GIS 2015

3.17.1.1 Night Skies

The Forest Service does not manage lands specifically for preserving dark night skies. However, lands adjacent to the project area are managed by the NPS, and the NPS is mandated to preserve, to the greatest extent possible, the natural lightscapes of the parks, which are natural resources and values that exist in the absence of human-caused light (NPS 2006b). Therefore, the affected environment for night skies adjacent to the project area is discussed below in order to provide a comprehensive cumulative analysis.

The natural lightscape plays a role in natural resource processes and affects biological behavior, as well as being a feature that contributes to visitor experience. The VCNP's high elevation, excellent air quality, low population density, and frequent cloud-free weather afford world-class viewing and enjoyment of naturally dark, star-filled skies. The unfettered view of the Milky Way, planets, meteors, and galaxies is increasingly becoming a major reason for many to visit the park.

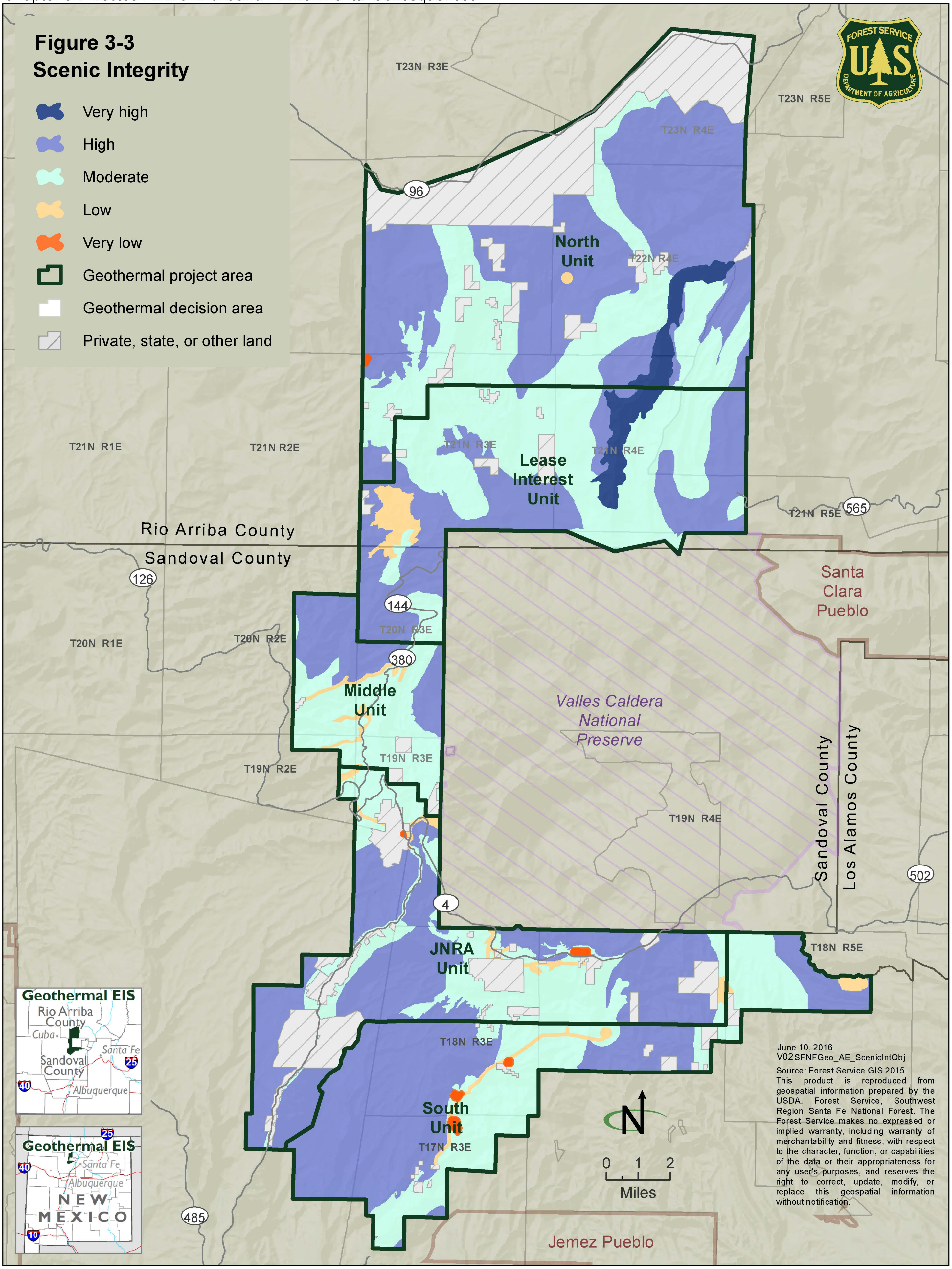
Figure 3-3
Scenic Integrity
Very high
High
Moderate
Low
Very low
Geothermal project area
Geothermal decision area
Private, state, or other land
T23N R3E
T23N R5E
T23N R4E
96
North Unit
T22N R4E
T21N R1E
T21N R2E
T21N R3E
Lease Interest Unit
T21N R4E
T21N R5E
565
Rio Arriba County
Sandoval County
126
144
T20N R3E
T20N R1E
T20N R2E
380
Middle Unit
Santa Clara Pueblo
Valles Caldera National Preserve
T19N R3E
T19N R2E
T19N R4E
Sandoval County
Los Alamos County
502
4
JNRA Unit
T18N R5E
T18N R3E
South Unit
T17N R3E
485
Jemez Pueblo
N
0 1 2
Miles
Geothermal EIS
Rio Arriba County
Cuba
Sandoval County
Santa Fe
Albuquerque
25
40
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
10
June 10, 2016
V02 SFNFGeo_AE_ScenicIntObj
Source: Forest Service GIS 2015
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Although night sky measurements have not yet been made at VCNP, they have been made at a nearby Bandelier National Monument fire tower, located approximately 6 miles east of the project area boundary. Light is evaluated through Lux. Lux is the unit of light measurement taking area into consideration (i.e., light intensity). **Table 3-19**, Examples of Lux Measurements on a Given Surface, provides examples of lux pertaining to different origins of light illuminated on a surface. Measurements at the Bandelier National Monument fire tower in 2005 identified a maximum vertical illuminance of 1.11 millilux with an estimated artificial contribution of 0.44 millilux. Measurements in 2006 identified a maximum vertical illuminance of 1.24 millilux with an estimated artificial contribution of 0.73 millilux (NPS 2005; 2006c).

Table 3-19. Examples of Lux Measurements on a Given Surface

Illuminance	Surfaces illuminated by:
0.0001 lux	Moonless, overcast night sky (starlight)
0.0014 lux	Venus at brightest
0.002 lux	Moonless clear night sky with airglow
0.1 lux	Quarter moon
0.27–1.0 lux	Full moon on a clear night
3.4 lux	Dark limit of civil twilight under a clear sky

Source: Schlyter 2006; Bunning and Ilse 1968

Dark sky conditions in the project area and the adjacent VCNP are likely to be similar to those recorded at the Bandelier National Monument fire tower. However, because factors that influence dark skies (e.g., distance populated areas, elevation, topography, and other sources of human-caused light), vary between the location of recorded measurements and the project area, overall maximum vertical illuminance and estimate artificial illuminance values may not be identical.

3.17.1.2 Adjacent Landscapes

Landscapes adjacent to the project area include undisturbed natural settings consisting of forest cover, volcanic landforms, and other geologic features. The VCNP is located adjacent to the project area, and important visitor use areas in the VCNP include the caldera rim and Redondo Peak. The viewshed from the caldera rim and Redondo Peak (for objects up to 35 meters in height) is shown in Figure 3-4, Redondo Peak and Caldera Rim Viewsheds. This viewshed covers approximately 119,300 acres (61 percent) in the project area, including lands not managed by the Forest Service.

3.17.2 Environmental Consequences

3.17.2.1 Scoping Comments on Resource

The following issues specific to visual resources were identified during the public scoping period:

- What are the visual impacts associated with geothermal leasing, including construction of transmission lines and water vapor from geothermal plants?

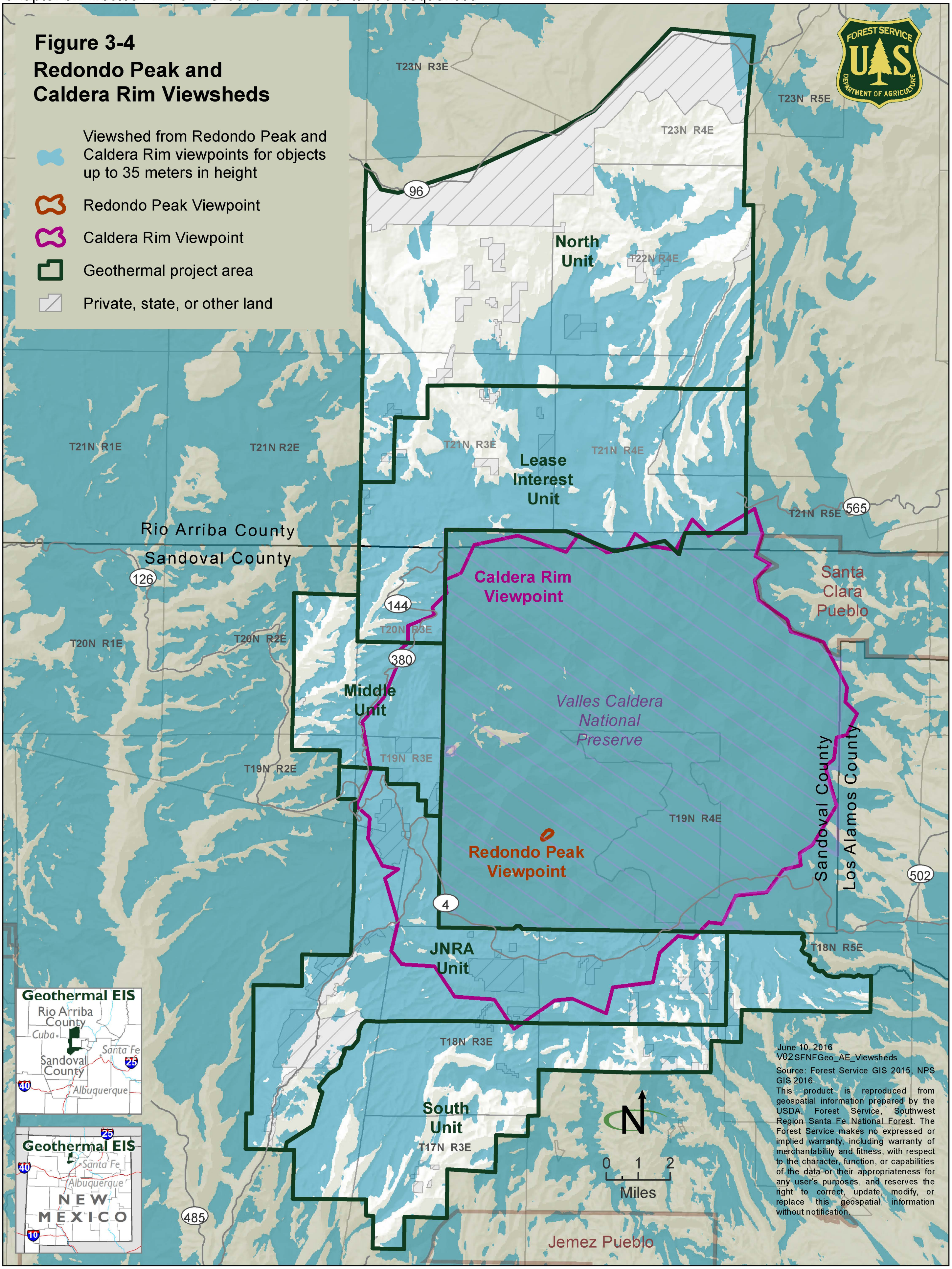
Figure 3-4
Redondo Peak and
Caldera Rim Viewsheds
Viewshed from Redondo Peak and Caldera Rim viewpoints for objects up to 35 meters in height
Redondo Peak Viewpoint
Caldera Rim Viewpoint
Geothermal project area
Private, state, or other land
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
T23N R3E
T23N R4E
T23N R5E
T22N R4E
North Unit
Lease Interest Unit
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
Rio Arriba County
Sandoval County
Caldera Rim Viewpoint
Santa Clara Pueblo
T20N R1E
T20N R2E
T20N R3E
Middle Unit
Valles Caldera National Preserve
T19N R2E
T19N R3E
T19N R4E
Redondo Peak Viewpoint
Sandoval County
Los Alamos County
JNRA Unit
T18N R5E
T18N R3E
South Unit
T17N R3E
Jemez Pueblo
96
126
144
380
4
565
502
485
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
25
40
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
10
N
0 1 2
Miles
June 10, 2016
V02 SFNFGeo_AE_Viewsheds
Source: Forest Service GIS 2015, NPS GIS 2016
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3.17.2.2 How Resource Impacts Were Evaluated

Method

The impact analysis for visual resources was based on review of existing baseline data for the project area as described under Affected Environment and information gathered through scoping. To the extent practical, spatial data were used to compare environmental conditions with the alternatives. Various actions that might create changes to the basic landscape elements were considered in identifying potential impacts. The region of influence for direct and indirect impacts is the decision area.

Indicators

Potential impacts on visual resources could occur if reasonably foreseeable future actions were to:

- Have impacts on a scenic vista;
- Degrade the existing visual character or quality of the site and its surroundings;
- Create a new source of light or glare; or
- Be incompatible with the scenic integrity.

Assumptions

Receptors sensitive to disturbances of visual resources are varied and depend on the landscape's visual resources; the project's location; the view distance, angle, and duration; the location of travel routes; public areas of interest; the season; the topography; recreation activities; and the number of viewers. Because of this, it is important to note that site-specific impact assessment is needed to thoroughly assess impacts on visual resources from a particular project. Without precise information about a specific project, it is not possible to detail the visual impacts. However, by using the RFDS as a general description of expected geothermal resource development activities, a generalized assessment of the possible impacts on visual resources can be made by describing the range of expected visual changes.

The assumptions for this analysis are:

- Other visual impact mitigation measures would likely be required at the project-specific phase of analysis and permitting;
- Scenic resources will remain in demand on public lands;
- Any new surface-disturbing geothermal activities would be subject to further NEPA analysis, which would include an analysis to determine consistency with applicable visual resource objectives.

3.17.2.3 Common Impacts Associated with Geothermal Development

The common impacts associated with geothermal development are described in the Final Programmatic EIS for Geothermal Leasing in the Western United States (BLM and Forest Service 2008). Additional impacts associated with light pollution and dark skies are discussed below.

Light pollution, defined as stray unwanted light outside the range and timing of natural variation, is not only an ecological disrupter, but also may affect the natural scenery of the night.

Light pollution has been documented over 200 miles from the light source (Chespesiuk 2009). The cumulative effect of multiple artificial light sources at varying distance brightens the sky background, drowning out stars and astronomical objects by contrast reduction, and increasing the luminance of the ground surface. Particularly dark night skies are most prone to a degradation of their scenic potential, showing a large reduction in the number of visible stars with a small amount of light pollution. Night skies already brightened by artificial light show a lessening degradation with each incremental increase in light pollution. Within this response function may be embedded thresholds whereupon certain species, ecological processes, or key scenic resources would be affected (Longcore and Rich 2004).

The degree of impact of artificial light is highly dependent on the distance and the type and brightness of the light fixture. Atmospheric characteristics such as humidity and particulates further influence the apparent effect of artificial light. Whether the light fixture is fully shielded is also important; fully shielded fixtures can greatly decrease the creation of both point and diffuse source light pollution (Falchi et al. 2011). The perception of light pollution would vary from one location to another caused by differences in vegetation cover, sight lines and horizon visibility, and even the color of the ground. Atmosphere of greater clarity tends to amplify distant light sources and attenuate nearby light sources, while more humid and polluted air tends to amplify close light sources.

While there is a canopy layer of vegetation in most of the project area and adjacent NPS lands, subsequent geothermal development could increase the amount of artificial lighting and could increase the potential for skyglow into adjacent landscapes such as the VCNP. This is especially true for the horizon, the part of the sky in which lightscape impacts are first noted. Air quality considerations can play a role in the context of lightscape impacts, because the presence of air pollution can increase light scattering.

Distance is the most influential factor in determining skyglow, because the brightness of skyglow from a given light source decreases six times for every doubling of distance (point light sources decrease four times for every doubling of distance). The distance for lighting on a drill rig to diminish to the level equivalent to a clear moonless night with airglow on a surface—or 0.002 lux—is approximately 10,000 feet, or two miles[14].

Light measurement data collected in April 2016 from a drilling rig near Big Thicket National Preserve, Texas, provided the basis for the extrapolation of collected data to define the distance of the affected environment. This survey data is representative of a typical drilling rig. Using this information, the strongest direction that light shined from the source was south with 1.3 lux at 300 feet. Since this was the strongest light direction and the variability of the drill rig orientation can change on future well drilling projects, this direction was used to produce a radius that would show the largest distance light would travel from the source in any direction. The final distance light would need to travel to reach 0.002 lux is 10,000 feet in all directions, providing no obstructions. This distance does not take anthropogenic and natural barriers, such as walls and vegetation, which would drastically reduce this distance[15].

[14] Randy Stanley, Natural Sounds and Night Skies Coordinator, NPS, letter to Forest Service regarding night skies. April 28, 2016.
[15] Randy Stanley, Natural Sounds and Night Skies Coordinator, NPS, letter to Forest Service regarding night skies. April 28, 2016.

3.17.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area, except for nondiscretionary closures (i.e., the JNRA). Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations.

The JNRA would remain closed to geothermal leasing. Visual resources would be protected in this area.

In the remainder of the decision area, visual resources could be impacted from subsequent geothermal exploration and development. It is likely that some form of mitigation would be required in areas of very high or high scenic integrity. In addition, due to the generally greater visual variety of the landscape in these areas, some development can be more easily hidden from view of the casual observer. In moderate, low, and very low scenic integrity areas, new development may not be as easily hidden. However, areas with existing development may be able to absorb new development without much change in the overall landscape.

3.17.2.5 Impacts Under Alternative 2

The JNRA would remain closed to geothermal leasing. An additional 10,400 acres would also be closed to geothermal leasing. Visual resources would be protected in these areas.

In addition to areas closed to leasing, 132,900 acres would be subject to NSO stipulations. This would preclude surface occupancy in these areas and visual resources would be preserved in the same way that areas closed to leasing would be protected. This includes all lands of very high scenic integrity.

The remaining 3,700 acres not either closed or subject to NSO stipulations are in the Lease Interest Unit and North Unit. High scenic integrity landscapes in this area would be subject to CSU stipulations. This stipulation would not prohibit development in the area, but development would need to take into consideration scenic values. The CSU stipulation would require that visual quality objectives be met within 5 years from project startup, reducing impacts on visual resources in the long term. While few existing modifications are in high scenic integrity landscapes, these landscapes generally have diverse topography, colors, and vegetation features that can be used to screen development from sight of the casual observer.

Few areas (1,400 acres) are not subject to any stipulations. Where this occurs, the scenic integrity is either moderate or low. This means that the landscape character is slightly or moderately altered. Often times these landscapes have less visual variety than areas with very high or high scenic integrity, making it more difficult to blend disturbances with the landscape, particularly where few are currently present. However, some level of disturbance that is noticeable to the casual observer is allowed in these areas.

3.17.2.6 Impacts Under Alternative 3

Under Alternative 3, no leasing would be permitted. There would be no impacts associated with geothermal development and the characteristic landscape would be retained.

3.17.2.7 Impacts Under Alternative 4

The JNRA would remain closed to geothermal leasing. Visual resources would be protected in this area.

In addition to the JNRA, 122,500 acres would be subject to NSO stipulations. None of the NSO is specifically to protect visual resources. However, visual resources would be incidentally protected. The impacts would be the same as described under Alternative 2.

The remaining 17,200 acres not either closed or subject to NSO stipulations are in the Lease Interest Unit and North Unit. Very high and high scenic integrity landscapes in this area would be subject to CSU stipulations. Impacts would be the same as described under Alternative 2.

Few areas are not subject to any stipulations. Where this occurs, the scenic integrity is either moderate or low. Impacts would be the same as under Alternative 2, but over a slightly larger area as there would be more acres not subject to stipulations under this alternative.

3.17.2.8 Cumulative Impacts

The region of influence for cumulative impacts is the viewshed of the decision area and adjacent landscapes.

Development of geothermal resources could result in cumulative impacts on visual resources across the project area when combined with other projects. The heights, type, and color of drilling equipment and power plants, together with their placement with respect to local topography, are factors that would contribute to determining the extent of visual intrusion on the landscape. Also, the development of transmission lines to connect new electrical production facilities to the regional power grid could contribute to cumulative impacts. Stipulations for the protection of visual resources including areas with very high and high scenic integrity would minimize impacts on visual resources.

Cumulative impacts on night skies and adjacent landscapes may occur. These impacts are described by alternative below.

Alternative 1

Night Skies

Under Alternative 1, geothermal exploration, drilling, and utilization as described in the RFDS (BLM 2015) would result in new artificial light sources in the project area. These light sources would likely increase the artificial contribution of skyglow in the project area, and potentially adjacent landscapes such as the VCNP, as described under *Common Impacts Associated with Geothermal Development*. The quantitative increase in artificial illuminance for adjacent lightscapes would ultimately depend on factors such as topography, the distance to VCNP, and vegetation cover. Wells within 2 miles of the VCNP boundary would be most likely to increase the artificial contribution of skyglow in the VCNP.

Adjacent Landscapes

Geothermal development under Alternative 1 may occur in the Redondo Peak and caldera rim viewsheds. In general, visual impacts from well rigs would be short term, while visual impacts from powerplants, powerlines, and other utilization infrastructure would be long term. Impacts on adjacent landscapes would be evaluated on a case-by-case basis.

Alternative 2

Night Skies

Cumulative impacts on night skies would be similar to those described under Alternative 1. However, discretionary leasing closures and stipulations would limit areas of potential development near the VCNP boundary, as shown in **Table 3-20**, below.

Table 3-20. Stipulations and Closures within a 1- and 2-mile Buffer of NPS Lands for Action Alternatives

	Alternative 2	Alternative 3	Alternative 4
	1 mile from NPS Lands		
Decision Area Lands	23,700	23,700	23,700
Closed	9,500	23,700	8,300
NSO	14,200	0	13,800
CSU	8,900	0	13,700
TL	5,000	0	6,100
Open Subject to Standard Lease Terms and Conditions	0	0	100
	2 miles from NPS Lands		
Decision Area Lands	49,200	49,200	49,200
Closed	17,900	49,200	15,500
NSO	27,200	0	26,000
CSU	14,600	0	26,500
TL	9,300	0	11,600
Open Subject to Standard Lease Terms and Conditions	0	0	400

Source: Forest Service GIS 2015

Under Alternative 2, there would be no lands open to geothermal leasing, subject to standard lease terms and conditions, within a 2-mile buffer of NPS lands. Geothermal development could potentially occur within 2 miles of NPS lands, resulting in increased artificial lighting. However, implementing BMPs as described in Appendix C (such as topography and vegetation screening, and minimum lighting design) would reduce the likelihood of increasing skyglow in the project area and adjacent NPS lands.

Adjacent Landscapes

Geothermal development under Alternative 2 could potentially occur in the viewshed of the caldera rim and Redondo Peak. However, geothermal leasing closures and stipulations would restrict where development could occur, as shown in **Table 3-21**, below.

Under Alternative 2, the majority of decision area lands in the viewshed would be closed to leasing or NSO. Approximately 1,100 acres in the viewshed would be open to leasing, subject to standard lease terms and conditions. Geothermal developments such as wells, power plants, and powerlines may be visible from the caldera rim, Redondo Peak, and other landscapes adjacent to the project area, which may detract from the visual character of these areas. However, implementing BMPs described in Appendix C would minimize the potential impacts on adjacent landscapes.

Table 3-21. Viewshed Acres from the Caldera Rim and Redondo Peak by Action Alternative[1]

	Alternative 2	Alternative 3	Alternative 4
Decision Area Lands	111,300	111,300	111,300
Closed	28,800	111,300	25,900
NSO	80,000	0	73,200
CSU	48,000	0	74,000
TL	26,900	0	29,500
Open Subject to Standard Lease Terms and Conditions	1,100	0	3,100

Source: Forest Service GIS 2015; NPS GIS 2016
[1]for objects up to 35 meters in height

Alternative 3

There would be no cumulative impacts on visual resources under Alternative 3

Alternative 4

Night Skies

Cumulative impacts on night skies would be similar to those described under Alternative 2. However, because there would be more acres open to leasing, subject to standard terms and conditions (approximately 400 acres) within a 2-mile buffer of NPS lands, there would be a greater potential for development near the NPS boundary and, therefore, a greater potential for increased skyglow in these areas. Because the location of geothermal developments is unknown, the magnitude of impacts is unknown.

Adjacent Landscapes

Impacts on adjacent landscapes would be similar to those described under Alternative 2. However, because there would be more acres open to leasing subject to standard lease terms and conditions (approximately 3,100 acres) within the viewshed of the Redondo Peak and the caldera rim, there would be an increased likelihood for development in this area and greater impacts.

3.18 Social Interests, Economics and Environmental Justice

3.18.1 Affected Environment

The construction and operation of geothermal power plants contributes to local, state, and national economies by creating jobs, generating property taxes, paying revenues, and making voluntary contributions to communities. The use of NFS lands in the project area for geothermal energy development affects the demographic characteristics and economies of the project area. Additionally, social structure and values in the project area shape the demand and opportunities created by NFS lands.

For these reasons, demographic, economic, and social data for the project area are presented in this section. Counties that fall within the project area were selected as the region of interest (ROI) for socioeconomic and environmental justice analysis because the impacts of leasing are likely to occur within this region. The ROI is Rio Arriba and Sandoval Counties.

A summary of the population, housing, and low-income and minority populations for each county is provided, based primarily on data from US Census 2010 and 2014 population estimates, demographic and housing information from the US 2010 Census, and employment and industry information from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis.

3.18.1.1 Population

The project area is in Rio Arriba and Sandoval Counties. Rio Arriba is in north-central New Mexico, bordering Colorado to the north, Taos and Mora Counties to the east, Santa Fe, Los Alamos, and Sandoval Counties to the south, and San Juan County to the west.

Rio Arriba County has a land area of 5,860.84 square miles and a population density of 6.9 persons per square mile, with a total population of 40,155 (US Census Bureau 2014). Population growth is expected to be slow for Rio Arriba County over the next 20 years. Estimates conclude that by 2035, the county will have a population of approximately 47,000 people (Alcantara 2008).

Sandoval County is directly south of Rio Arriba and is part of the Albuquerque metropolitan statistical area. Sandoval County borders Los Alamos and Santa Fe Counties to the east, Bernalillo County to the south, and Cibola, McKinley, and San Juan Counties to the west.

Sandoval County has a land area of 3,710.65 square miles and a population density of 35.5 persons per square mile, with a total population of 135,191 (US Census Bureau 2014). Unlike Rio Arriba County, the Sandoval County population is projected to grow quickly and will exceed 200,000 people by 2035; this will result in a 68 percent growth in population over the next 20 years. New Mexico as a whole is also estimated to experience quick population growth, by nearly 70 percent between 2014 and 2035. This growth will be concentrated in and around the metropolitan centers of Albuquerque, Santa Fe, and Las Cruces (Alcantara 2008).

Table 3-22, below, describes population data for 2010 and 2014. Rio Arriba's total population decreased by 1 percent between 2010 and 2014; Sandoval's population increased by approximately 1 percent during the same period, narrowly outpacing average population growth in both New Mexico and the United States (US Census Bureau 2014).

Table 3-22. Population by County, State, and Country

Location	2010	2014	2010-2014 Percent Change
United States	303,965,272	314,107,084	+1.03
New Mexico	2,013,122	2,080,085	+1.03
Rio Arriba County	40,195	40,155	-0.99
Sandoval County	124,263	135,191	+1.09

Source: US Census Bureau 2010, 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

*Percent change rounded to the nearest hundredth.

3.18.1.2 Housing

Table 3-23, below, provides data on the number of housing units for 2010 and 2014 for Rio Arriba and Sandoval Counties. The total housing supply for both counties grew between 2010 and 2014.

Table 3-23. Housing Units by County, State and Country

Location	2010	2014	2010-2014 Percent Change
United States	130,038,080	132,741,033	+1.02
New Mexico	887,890	907,233	+1.02
Rio Arriba County	19,385	19,601	+1.01
Sandoval County	50,314	53,289	+1.06

Source: US Census Bureau 2010, 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

*Percent change rounded to the nearest hundredth.

Table 3-24, below, shows the vacancy rate for Rio Arriba and Sandoval Counties as 23 percent and 10.8 percent. Vacancy rates can be indicators of rental property income, property values, unemployment rates, disposable income, and overall economic conditions in a region (US Census Bureau 2010). A significant portion of vacant housing in both counties is classified for seasonal or recreation use.

Table 3-24. Housing Vacancy Status 2010

	United States	New Mexico	Rio Arriba County	Sandoval County
Vacancy rate	12.2%	14.8%	23.0%	10.8%
Vacant housing units	14,988,438	109,993	3,870	4,685
For rent	4,137,567	22,150	373	594
Rented, not occupied	206,825	1,303	38	51
For sale only	1,896,796	11,050	179	894
Sold, not occupied	421,032	2,143	45	170
For seasonal, recreational, or occasional use	4,649,298	36,612	1,709	1,532
For migratory workers	24,161	229	8	4
Other vacant	3,652,759	36,506	1,518	1,440

Source: US Census Bureau 2010

In 2014, as shown in **Table 3-25**, below, the Rio Arriba County median home value was $140,900. This was below the New Mexico and national median home value. The median home value in Sandoval County was $175,800, well above the New Mexico median home value and nearly equivalent to the national median home value. Median gross rent for Rio Arriba County was $644, also below New Mexico and national median gross rent. Sandoval County median gross rent was $997, which was higher than the New Mexico and national median gross rents. Sandoval County is part of the Albuquerque metropolitan area, which accounts for its higher median home values and median gross rent.

Table 3-25. Median Home Values and Median Gross Rent 2014

Location	Median Home Value	Median Gross Rent
United States	$175,700	$920
New Mexico	$159,300	$774
Rio Arriba County	$140,900	$644
Sandoval County	$175,800	$997

Source: US Census Bureau 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

Property taxes are a substantial source of revenue for Rio Arriba and Sandoval Counties. The weighted average property tax rate, or mill levy, is calculated by weighing tax rates in proportion to the taxable value of the tax district in which the rates appear. The property tax rate for Rio Arriba County in 2015 was $18.643 per $1,000 of net taxable value for residential property and $28.231 per $1,000 for nonresidential property. The property tax rate for Sandoval County in 2015 was $33.241 per $1,000 of net taxable value for residential property and $36.194 per $1,000 for nonresidential property (NMDFA 2015). In comparison, the mean residential property tax rate for New Mexico was $29.751 per $1,000 of net taxable value and the mean nonresidential property tax rate for New Mexico was $31.252 per $1,000 of net taxable value (NMDFA 2015). Property tax obligations (revenue, assuming 100 percent collection) and assessed values are shown in **Table 3-26**, below.

Table 3-26. Santa Fe Geothermal Leasing Study Area - Property Tax Assessed Values and Obligations

Location	Residential		Nonresidential	
	Total Assessed Value	Tax Obligation	Total Assessed Value	Tax Obligation
Rio Arriba County				
2014	$497,972,317	$8,857,470	$304,893,136	$7,943,607
2015	$503,272,606	$9,382,526	$289,642,902	$8,176,899
Percent change	1.01	1.06	-0.95	1.02
Sandoval County				
2014	$2,427,832,009	$79,541,120	$751,460,176	$26,774,991
2015	$2,459,906,995	$81,769,053	$738,900,559	$26,743,586
Percent change	1.01	1.02	-0.98	-1.00
State of New Mexico				
2014	$31,574,705,479	$929,779,057	$17,003,242,702	$528,806,372
2015	$32,283,583,025	$960,480,174	$17,454,632,250	$545,494,747
Percent change	1.02	1.03	1.02	1.03

Source: NMDFA 2014, 2015

3.18.1.3 Employment

Table 3-27, below, provides the average unadjusted unemployment rate for each year by county. Both Rio Arriba and Sandoval Counties saw an overall decrease in unemployment over this period, by 1.2 percent and 1.8 percent, following state and national trends (BLS 2015).

Table 3-27. Santa Fe Geothermal Leasing Study Area - Average Yearly Unadjusted Unemployment Rate by County from 2010-2015

Location	Percent Unemployed					
	2010	2011	2012	2013	2014	2015
United States	9.6	9.0	8.1	7.4	6.2	5.3
New Mexico	8.1	7.6	7.1	6.9	6.5	6.5
Rio Arriba County	9.1	9.2	9.1	9.2	8.3	7.9
Sandoval County	8.4	8.1	7.8	7.5	7.1	6.6

Source: BLS 2015

Unemployment rates remained consistently higher than the New Mexico rate in Rio Arriba County and slightly above the state rate in Sandoval County over the period examined.

In December 2014, the labor force of Rio Arriba County consisted of 16,356 people; 14,995 were employed and 1,361 were unemployed (BLS 2015). Sandoval County had a labor force of 59,968 people; 55,711 were employed and 4,257 were unemployed as of December 2014 (BLS 2015).

3.18.1.4 Income

Table 3-28, below, shows median household incomes for years 2010 and 2014. The median household income for Rio Arriba County was $38,635 in 2014; this is a decrease in median household income by $2,802 from 2010 and falls below the New Mexico and United States median household incomes (US Census Bureau 2014). Sandoval County's median household income decreased less significantly from 2010 to 2014; at $57,092 in 2014, it is above both the New Mexico and United States median household incomes (US Census Bureau 2014).

Table 3-28. Median Household Income

Location	2010	2014
United States	$51,914	$53,482
New Mexico	$43,820	$44,968
Rio Arriba County	$41,437	$38,635
Sandoval County	$57,158	$57,092

Source: US Census Bureau 2010, 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

Table 3-29, below, shows average income across the total population for Rio Arriba and Sandoval Counties in 2010 and 2014.

Table 3-29. Per Capita Income

Location	2010	2014
United States	$27,334	$28,555
New Mexico	$22,966	$23,948
Rio Arriba County	$19,913	$19,483
Sandoval County	$25,979	$26,916

Source: US Census Bureau 2010, 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

3.18.1.5 Key Economic Sectors Related to Forest Service Management

Tourism

Revenues and employment opportunities associated with travel and tourism are important sources of income in Rio Arriba and Sandoval Counties. Based on data from a 2014 National Forest Service Visitor Use and Monitoring report, the average total trip spending on a visit to the Santa Fe region of the SFNF was $230, while the median was $25 (Forest Service 2014b). Visitors planned overnight stays within 50 miles of the National Forest 21 percent of the time and stayed an average of 4.9 nights per trip within 50 miles of SFNF (Forest Service 2014b). In 2009, an estimated 1,496,000 people visited the SFNF (Harris 2014). In 2014, the travel and tourism sector accounted for 11.7 percent of total employment in Rio Arriba County and 14.3 percent in Sandoval County (Headwaters Institute 2016b). A significant majority of these employment opportunities come from the accommodations and food services industries.

Mineral Development

For fiscal year 2014, neither Rio Arriba nor Sandoval County received any royalty payments from the federal government for geothermal leases on federal lands or royalty payments from any fluid mineral development on federal land (Headwaters Institute 2016a).

Grazing

Royalties from grazing leases on federal lands can be significant sources of revenue for local county governments. Rio Arriba County received $32,043 in federal lands payments from grazing districts in fiscal year 2014; Sandoval County received $46,641 in federal lands payments from grazing districts in the same year (Headwaters Institute 2016a).

Community Services

Rio Arriba County has two sheriff’s office locations, one in Tierra Amarilla, the county seat, and one in Espanola. There are 18 fire districts in Rio Arriba County; it is serviced by 12 emergency management stations and a county public works office (Rio Arriba County 2016). Sandoval County is serviced by 8 fire districts and 20 fire stations, with nearly 300 volunteer and full-time firefighters (Sandoval County 2016). Its sheriff’s office is in San Bernalillo. Both counties are also serviced by New Mexico state police districts (New Mexico State Police 2016).

3.18.1.6 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires that federal agencies identify and address any disproportionately high and adverse human health or environmental impacts of their programs, policies, and activities on minority, low-income populations and Native Americans. Guidance on environmental justice terminology developed by the President’s Council on Environmental Quality provides the following definitions:

A low-income population is determined based on annual statistical poverty thresholds developed by the US Census Bureau. In 2014, the poverty level is based on a total income of $12,316 for an individual under age 65 and $24,418 for a family of four (DeNavas-Walt and Proctor 2015)

- A low-income community may include either a group of individuals living in geographic proximity to one another or dispersed individuals, such as migrant workers or Native Americans.

- Minorities are individuals who are members of the following population groups: American Indian, Alaska Native, Asian, Pacific Islander, Black, or Hispanic.
- A minority population area is so defined if either the aggregate population of all minority groups combined exceeds 50 percent of the total population in the area, or if the percentage of the population in the area comprising all minority groups is meaningfully greater than the minority population percentage in the comparison population. Like a low-income population, a minority population may include either individuals living in geographic proximity to one another or dispersed individuals.
- For the purpose of identifying a minority population or a low-income population concentration, the comparison population used in this study is the state of New Mexico as a whole.

To analyze low-income and minority populations in the project area, study area counties and relevant census tract data was examined. Rio Arriba Census Tract 4, Rio Arriba Census Tract 5, Sandoval Census Tract 110, and Sandoval Census Tract 112 all overlap the project area and are more representative of populations in the project area than data taken from Rio Arriba or Sandoval Counties as a whole.

3.18.1.7 Low-Income Populations

Rio Arriba Census Tract 5, Sandoval Census Tract 110, and Sandoval Census Tract 112 all had percent of populations in poverty lower than that of the State of New Mexico (see **Table 3-30**).Only Rio Arriba County and Rio Arriba Census Tract 4, with 22.5 percent of individuals below the poverty level, had a percentage of the population in poverty greater than New Mexico (US Census Bureau 2014).

Table 3-30. Populations in Poverty 2014

Location	Percent of Individuals Whose Income in the Past 12 Months Was below the Poverty Level	Percent of Families Whose Income in the Past 12 Months Was below the Poverty Level
United States	15.6	11.5
New Mexico	20.9	16.1
Rio Arriba County	22.5	15.8
Rio Arriba County, Census Tract 4	22.5	12.8
Rio Arriba County, Census Tract 5	15.4	12.2
Sandoval County	14.7	10.7
Sandoval County, Census Tract 110	19.2	14.4
Sandoval County, Census Tract 112	14.2	12.1

Source: US Census Bureau 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time.

3.18.1.8 Minority Populations

As shown in **Table 3-31**, all study area populations were above 50 percent minority. Rio Arriba Census Tract 4, Rio Arriba Census Tract 5, and Sandoval Census Tract 110 had aggregate minority populations that were greater than the New Mexico aggregate minority population. Minority populations were also identified in Sandoval Census Tract 112, with 57 percent of the population identifying as a minority, although this was less than the New Mexico aggregate minority population (US Census Bureau 2014).

Table 3-31. Study Populations by Race/Ethnicity 2014

Population	Tract 4, Rio Arriba County	Tract 5, Rio Arriba County	Tract 110, Sandoval County	Tract 112, Sandoval County	Rio Arriba County	Sandoval County	New Mexico	United States
Total population	4,504	3,548	1,859	2,676	40,155	135,191	2,080,085	314,107,084
Hispanic or Latino ethnicity of any race	77.5%	65.2%	32.7%	17.1%	71.4%	36.4%	47.0%	16.9%
White alone	21.6%	31.3%	25.4%	42.9%	13.1%	46.1%	39.6 %	62.8%
Black or African American alone	0.4%	0.3%	1.0%	0.0%	0.4%	2.0%	2.0%	12.6%
American Indian or Alaskan Native alone	1.5%	3.4%	36.5%	39.8%	14.0%	11.9%	9.2%	0.8%
Asian alone	0.0%	0.1%	0.7%	0.8%	0.5%	1.3%	1.4%	5.0%
Native Hawaiian and Other Pacific Islander alone	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%
Some other race	11.9%	4.9%	9.8%	5.0%	0.1%	0.4%	11.1%	4.7%
Two or more races	0.2%	1.0%	4.0%	0.4%	0.5%	1.9%	3.1%	2.9%
Aggregate Minority population	78.4%	68.7%	74.6%	57.1%	86.9%	53.9%	60.4%	36.2%

Source: US Census Bureau 2014

Note: American Community Survey estimates are based on data collected over five years. They represent the average characteristics of populations between January 2010 and December 2014 and do not represent a single point in time. Aggregate minority population is calculated by total population, minus those reporting as white of non-Hispanic.

3.18.1.9 Native Americans

In Sandoval Census Tract 110, 678 persons identify as American Indian alone, out of a total population of 1,859. In Sandoval Census Tract 112, 1,065 persons identify as American Indian alone, out of a total population of 2,676 (US Census Bureau 2014).

As identified in **Table 3-31**, Study Populations by Race/Ethnicity 2014, all populations in the area have more than 50 percent aggregate minority populations, and therefore qualify as minority populations under CEQ guidance. The Forest Service will address environmental justice populations in the project area in the EIS to mitigate any disproportionate environmental impacts on these populations, following guidelines set forth in Executive Order 12898.

3.18.2 Environmental Consequences

3.18.2.1 Scoping Comments on Resource

The following issues specific to social interests, economics, and environmental justice were identified during the public scoping period:

- How would geothermal leasing affect tourism, local businesses, property value, and community services?
- Would geothermal leasing result in disparate impacts on communities, tribes, or other populations?

3.18.2.2 How Resource Impacts Were Evaluated

Method

Impacts were analyzed in terms of the predicted increase in geothermal energy activities and the associated changes expected in employment, income, tax revenue, royalties, property value, public infrastructure needs, impacts on other land uses, and other socioeconomic factors. The location of such development could occur anywhere in the project area where consent to leasing has been granted. Components of geothermal plant construction and operation, including the number of temporary and permanent workers required, are partially determined by plant production potential.

The analysis of socioeconomic and environmental justice issues associated with the development of geothermal facilities considers impacts within the counties of the project area: Rio Arriba and Sandoval.

Indicators

Impacts would result from the lease revenues and future construction and operation of geothermal energy projects in the project area, based on future leases. Consenting to geothermal leasing and issuing geothermal leases would not impact environmental justice. Potential impacts on socioeconomics and environmental justice could occur if reasonably foreseeable future actions were to result in any of the following:

- Impact other land uses that currently create revenue
- Change residential property value and property taxes collected
- Induce growth or otherwise change population concentrations and cause additional demands on housing or social services that could not be met by the local communities

- Cause a change in local or project area employment
- Have a disproportionately high and adverse impact on minority populations or a disproportionately high and adverse impact on low-income populations

Assumptions

- NSO stipulations would prevent direct disturbance to recreation, wildlife, visual resources, habitats, and species by restricting surface-disturbing activities where they are applied.
- Geothermal projects in the project area would be developed in accordance with the RFDS, suggesting a maximum of five geothermal plants of 25 MW each during the 15-year time frame, for a total of 125 MW.
- Jobs and economic activity generated are based on RFDS MW estimates and economic impact estimates from the Geothermal Leasing PEIS (BLM and Forest Service 2008).
- Any new surface-disturbing geothermal activities would be subject to further NEPA analysis, which would include a site-specific analysis to determine consistency with applicable environmental justice guidelines.

3.18.2.3 Common Impacts Associated with Geothermal Development

The issuance of geothermal leases would impact socioeconomics through lease revenues, with 50 percent of revenues going to the state, 25 percent going to the county, and the remainder going to the US Treasury (BLM and Forest Service 2008).

Impacts on area socioeconomics and environmental justice from developing the geothermal resource would vary, depending on the types, timing, and location of development. The largest impact on socioeconomics would result from employment and income directly and indirectly associated with geothermal electricity plant construction and operation. In addition, geothermal power plants may generate additional revenue streams for local government, including property taxes and royalties. Information and impacts for these factors are discussed at length in the 2008 Geothermal PEIS (BLM and Forest Service 2008), and this information is incorporated by reference and summarized here.

Activities associated with exploration and drilling provide temporary jobs for the local community near geothermal resources, as well as expenditures for fuel, lodging, food, and other needs, providing stimulus to the local economy.

The level of impact resulting from utilization phase activities (construction, operations, and maintenance) generally varies, depending on resource potential for the area. Based on the 2008 Geothermal PEIS (BLM and Forest Service 2008), construction income is estimated to be roughly $4.5 million per 25-MW power plant and associated activities. In summary, construction of a 25-MW power plant and the associated transmission lines would require 935 person-months, or 77.5 person-years, with a variable number of employees required at any given time during construction. Operations and maintenance income is estimated to be $1.6 million annually for a 25-MW plan.

Generally, employment would provide positive impacts on the surrounding area in the form of opportunities and secondary impacts from money spent in the local economy. Additionally, geothermal resource development may provide an opportunity to broaden the economic base of the communities in and around the project area and would provide taxes and possible royalties to the county.

3.18.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. Excluded from leasing would be the 28,900-acre JNRA. The social and economic impacts from geothermal development, should a lease application be approved, are described here.

Alternative 1 would result in impacts similar to those described in **Section 3.18.2.3**. The direct economic impacts from the construction and operation of the five 25-MW geothermal plants also include employment opportunities and federal royalties paid to the State of New Mexico and Rio Arriba and Sandoval Counties. Indirect impacts, such as increased economic activity and tax contributions, would also impact the area.

The creation of approximately 388 temporary construction jobs, only some of which would come from the local labor force, would have temporary impacts on the local economy (BLM and Forest Service 2008). The degree to which employment would be filled by area residents would depend on the level of skill required for particular jobs and the availability of qualified candidates, among other factors. While these jobs would be temporary, indirect impacts on local economies would be spending by these job holders on housing, goods, and services.

A short-term increased demand for housing might also occur. Such an increase is not anticipated to create a significant burden on local housing or social services markets or induce a level of growth that the local communities do not have a capacity for. This is because the number of construction workers needed at any given time would vary throughout the completion of the project.

Table 3-32, below, further details the direct economic impacts associated with geothermal electricity plant development. It is in accordance with expected development scenarios established in the RFDS (BLM 2015) and economic impacts from those scenarios from the Geothermal Programmatic EIS (BLM and Forest Service 2008).

Table 3-32. Economic Impacts of Geothermal Electricity Generation

Estimated geothermal MW	Five 25-MW geothermal plants = 125 MW
Total temporary construction jobs[1]	388
Construction income (million $)[2]	$22.5 million
Operations and maintenance jobs (permanent, full-time jobs)[3]	212
Annual operations and maintenance income[4]	$8 million
Federal royalty estimate (30-year total)[5]	$1.75 million
State royalty estimate (30-year total)[5]	$3.5 million
County royalty estimate (30-year total)[5]	$1.75 million

[1] Assuming an average of 3.1 total construction jobs per MW (BLM and Forest Service 2008)
[2] Assuming a rate of $4.5 million for a 25-MW power plant (BLM and Forest Service 2008)
[3] Assuming a rate of 1.7 permanent full time jobs/MW, in accordance with the Reasonably Foreseeable Design (BLM 2015)
[4] Assuming a rate of $1.6 million annually for a 25-MW power plant, as discussed in BLM and Forest Service (2008)
[5] With average electricity price of 6 cents/kilowatt hour and 95 percent capacity factor, following Kagel (2006)

Long-term employment projections from geothermal operations and maintenance could include up to 212 new jobs (BLM 2015). Geothermal projects employ people with a variety of skills and education levels in diverse careers, from geologists and hydrologists to plumbers, machinists, electricians, and structural engineers (Kagel 2006). Some of these jobs would employ members of the region’s current labor force, while some specialized positions may require hiring workers new to the region.

Short-term direct impacts for local area residents’ quality of life may occur as a result of project construction, due to increased traffic, noise, and dust from construction equipment (see Transportation and Access, Noise, and Air Quality and Air Quality Related Values sections). Impacts would be focused on those who live in the vicinity of development projects, and specific intensity and location of impacts would be variable, depending on the location of wells and plants, which are currently unknown. Because there is low housing density in the project area, these impacts would occur only in localized areas.

In addition to direct impacts, indirect impacts on social interests and economics might occur as a result of geothermal development under Alternative 1. Property tax values of lands near or next to the geothermal power plant could be impacted by the perceived decrease in scenic value from the development. However, because geothermal plants are of small footprint and must be located near existing power lines, these affects would be minimal and short-term. This is because much of the disturbed area would be reclaimed within a few years after the completion of construction.

Although some long-term employment opportunities may be created though geothermal development, the population, labor force, or employment sector of the region would not be greatly altered. The RFDS reports that 1.7 potential long-term jobs are created for every MW of a geothermal plant. Assuming geothermal development reaches its full potential of five 25-MW plants in the project area, 212 long-term jobs could result from development. Assuming the maximum long-term employment rate, that each person who receives a job must relocate to the project region, and that each person has an average size family of three persons, the total maximum increase in population would equal 636 people. This unlikely potential impact would result in a negligible 1.5 percent maximum population increase to Rio Arriba County or a negligible 0.5 percent maximum population increase to Sandoval County.

Recreation and tourism revenues might be reduced, but this would be limited to the construction phase of geothermal development. Hiking, hunting, wildlife viewing, sport climbing, and camping are all popular recreation activities in the area. Currently developed recreation facilities, special-use permit recreation sites, and areas with significant recreation use deemed incompatible with geothermal development would be closed to geothermal leasing. This would minimize impacts on current recreation and tourism revenues. Due to these stipulations and the dispersed nature of the popular activities, there would be minimal long-term impacts on revenues that come from recreation and tourism in the project area.

Alternative 1 is not site specific, and leasing would be approved on a case-by-case basis; therefore, uniform guidance, stipulations, closures, and consistent BMPs for leasing have not been identified under this alternative. This type of planning does not provide the best protections for natural resources, socioeconomics, or environmental justice populations. By designating specific areas as open or closed to leasing and imposing stipulations on direct and indirect land-use by geothermal development, impacts on natural resources, socioeconomics, and environmental justice populations can be minimized or negated. Without site-specific plans for geothermal development, impacts on environmental justice populations in the project area cannot be determined at this time.

3.18.2.5 Impacts Under Alternative 2

The overall economic impacts of geothermal development under Alternative 2 are the same as Alternative 1, but certain restrictions to leasing would apply. Under this alternative, 29,321 acres would be closed by law, regulation, or authority to geothermal leasing. Also, under this alternative, 139,329 acres would be open to leasing, but 132,900 of them would be subject to NSO stipulations, 80,300 would be subject to CSU stipulations, and 39,500 would be subject to TL stipulations (Forest Service GIS 2015).

The overall potential development of five 25-MW geothermal plants and the overall net economic impacts from such development would be the same as under Alternative 1, but Alternative 2 includes greater limitations for the siting of geothermal plants and infrastructure than Alternative 1. Site limitations may cause net economic impacts to be more dispersed throughout the ROI than under Alternative 1. NSO, CSU, and TL stipulations would limit potential development sites but would minimize the direct impacts on natural resources, such as wildlife, soil, and water. This reduced impact on natural resources indirectly impacts socioeconomics by improving the quality of life for residents of the surrounding project area and reducing impacts on recreation and other land uses that generate revenue for the local economy.

The programmatic nature of this EIS does not allow for analyzing specific environmental justice populations in the project area at this time. Site-specific considerations for environmental justice populations must occur to mitigate any disproportionately high and adverse impacts from geothermal development, in compliance with Executive Order 12898.

3.18.2.6 Impacts Under Alternative 3

Under Alternative 3, no leasing would be permitted, and no new employment opportunities, federal royalty payments, or new taxable income would be generated. There would be no impacts associated with geothermal development, and the current social and economic profile of the surrounding area would be retained.

3.18.2.7 Impacts Under Alternative 4

The overall economic impacts of geothermal development under Alternative 4 are the same as under Alternative 1, but certain restrictions to leasing would apply. Under this alternative, 28,900 acres would be closed by law, regulation, or authority to geothermal leasing. Also, under this alternative, 139,329 acres would be open to leasing, but 122,500 of them would be subject to NSO stipulations, 122,600 would be subject to CSU stipulations, and 42,200 would be subject to TL stipulations (Forest Service GIS 2015).

The overall potential development of five 25-MW geothermal plants and the overall net economic impacts from such development would be the same as under Alternative 1, but Alternative 4 includes greater limitations for the siting of geothermal plants and infrastructure than Alternative 1. Site limitations may cause net economic impacts to be more dispersed throughout the ROI than under Alternative 1. NSO, CSU, and TL stipulations would limit potential development sites but would minimize the direct impacts on natural resources, such as wildlife, soil, water, and air quality. This reduced impact on natural resources indirectly impacts socioeconomics by improving the quality of life for residents of the surrounding project area and reducing impacts on recreation and other land uses that generate revenue for the local economy.

The programmatic nature of this EIS does not allow for analyzing specific environmental justice populations in the project area at this time. Site-specific considerations for environmental justice populations must occur to mitigate any disproportionately high and adverse impacts from geothermal development, in compliance with Executive Order 12898.

3.18.2.8 Cumulative Impacts

Overall cumulative net impacts from geothermal development and other industrial projects also slated to occur in the ROI would generally result in increased economic activity in the region. Projects are the Pueblo of Jemez Red Rocks Dam Repair, the Pueblo of Jemez Owl Springs Bridge Sediment Removal, and the Abiquiu Land Grant Waterline Replacement. Impacts include the creation of jobs, increased royalties for local municipalities, increased tax revenue, and the securement of reliable utilities, such as clean potable water and electricity for the population. However, a cumulative increased demand for housing and social services from temporary construction employment, should these development projects overlap with geothermal development, could impact the local economy's ability to provide such services. The level of impacts would depend on the exact timing of development projects and the level of employment needs, which cannot be determined at this time.

Contribution to cumulative impacts would vary by Alternative. Following direct and indirect impacts discussed above, geothermal leasing under Alternatives 1, 2, and 4 would result in contributions to cumulative impacts, while no contributions to cumulative impacts would occur under Alternative 3 due to no geothermal leasing and development.

Geothermal development projects when combined with other industrial projects could cumulatively impact environmental justice populations in the project area identified in **Section 3.18.1.6**. Compliance with the environmental justice guidelines set forth in Executive Order 12898 would be necessary to ensure no disproportionately high and adverse impacts affect these identified populations.

3.19 Health and Safety

3.19.1 Affected Environment

The 2008 Geothermal PEIS describes health and safety concerns associated with geothermal energy development, as well as the regulatory framework around the health and safety of workers involved in such development. In the future, when NEPA analysis is conducted for specific geothermal exploration and development projects in the project area, site-specific health and safety risks would be documented. Existing health and safety risks in the project area relate to existing and ongoing mining and exploration, vegetation treatments, recreation, hunting, and transportation. In addition, there have been several major wildfires on the SFNF in recent years caused by trees or branches falling on small service lines.

3.19.2 Environmental Consequences

3.19.2.1 Scoping Comments on Resource

The issues specific to health and safety identified during the public scoping period are

- What are the health and safety risks of geothermal leasing? How would geothermal leasing affect drinking water, considering the regional geology?

3.19.2.2 How Resource Impacts Were Evaluated

Method

The method for the public health and safety impact analysis is incorporated by reference from the health and safety section of the 2008 Geothermal PEIS (BLM and Forest Service 2008).

Indicators

Impact criteria for public health and safety are also incorporated by reference from the health and safety section of the 2008 Geothermal PEIS (BLM and Forest Service 2008). More specifically, the analysis discusses the potential for the exposure of construction workers, personnel, or the public to hazards related to the exploration, development, or operational phases of a geothermal project. This section does not discuss hazards related to hazardous materials, because they were discussed separately under *Hazardous Materials*.

Assumptions

This analysis assumes the following:

- The risk of exposure to hazardous situations would be highest among geothermal project staff; the general public would have a lower risk of exposure due to the reduced likelihood of being on the project site during exploration, development, operations, and abandonment.
- All construction workers and operational personnel would work according to Occupational Health and Safety Administration standards to prevent or minimize health and safety risks.

3.19.2.3 Common Impacts Associated with Geothermal Development

The nature and characteristics of the impacts on public health and safety associated with geothermal development as a result of the decisions common to all action alternatives would be the same as those described in the 2008 Geothermal PEIS (BLM and Forest Service 2008), which is incorporated by reference and summarized here.

Due to the inability to predict the location, scope, scale, and timing of future development, what follows is a general description of common impacts on public health and safety from geothermal resource development. Potential impacts are as follows:

- Exposure of individuals to geothermal steam during exploration and development drilling
- Exposure of individuals to electrical fires or wildfires caused by project activities
- Exposure of individuals to electric shock from maintenance of transmission lines and substations
- Vehicular accidents due to increased traffic on local roads
- A variety of potential accidents inherent to exploration, development, operations, maintenance, and reclamation and abandonment, as listed in the Geothermal PEIS
- A variety of potential accidents inherent to industrial facilities

Potential public health and safety impacts would last for the duration of exploration, estimated at between one and five years for an individual project, development phase, estimated at two to ten years for an individual project, and operations and maintenance phase, estimated at 10 to 30 years for an individual project.

Impacts from drilling activities on drinking water quality are discussed in **Section 3.9**, Water Resources.

3.19.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis and in accordance with the Forest Plan and existing laws and regulations. Impacts would be similar to those identified in **Section 3.19.2.3**, *Common Impacts Associated with Geothermal Development*, above. Measures to minimize impacts on health and safety would be considered in these separate NEPA analyses.

There would be a risk of human-caused fire from geothermal development. However, because power line rights-of-way would be cleared of trees, the risk of wildfire associated with trees causing downed power lines would be minor. This is in contrast to smaller service lines associated with residences, where the right-of-way owner may not clear trees at a long enough distance to prevent them from falling on the line.

3.19.2.5 Impacts Under Alternative 2

The nature and character of impacts under Alternative 2 would be similar to those described in *Common Impacts Associated with Geothermal Development*. Under this alternative, the recommended BMPs detailed in Appendix C would be incorporated as appropriate into the permit application by the lessee or would be included in the approved use authorization as conditions of approval. Depending on which BMPs are identified as necessary for each lease, operators may be required to implement actions that would protect public health and safety. For example, operators would be required to minimize air quality impacts, develop hazardous materials and waste management plans, establish safety zones, and develop fire management strategies. These measures would effectively minimize impacts on health and safety from geothermal-related actions.

Impacts from wildfire and power lines would be the same as described under Alternative 1.

3.19.2.6 Impacts Under Alternative 3

There would be no lands available for leasing in the project area and no impacts on health and safety from geothermal activities.

3.19.2.7 Impacts Under Alternative 4

Impacts would be the same as those described under Alternative 2, because the same level of disturbance, the same number of wells, and the same number of power plants are expected.

3.19.2.8 Cumulative Impacts

Health and safety risks associated with geothermal energy activities, in conjunction with other reasonably foreseeable projects across the project area, are expected to be negligible. This is because all project proponents would have to comply with state and federal requirements pertaining to worker safety and the use, storage, transport, and disposal of debris and hazardous materials and wastes. The potential for spills of hazardous waste, such as fuel and drilling muds, would be minimized by applying BMPs included in lease terms. Any spills would not be at a large enough scale to cumulatively affect human health and safety, either at the local level, when combined with other local projects, or across the project area, when combined with all other projects with similar individual impacts. There would be no cumulative impact on wildfire from downed power lines, because power line rights-of-way associated with geothermal development would be maintained free of trees or other vegetation that could fall onto the line.

3.20 Noise

3.20.1 Affected Environment

The federal law that directly affects noise control is the Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978 (42 USC, Sections 4901-4918). This act delegates to the states the authority to regulate environmental noise. It also directs government agencies to comply with local community noise statutes and regulations and to conduct their programs to promote an environment free of any noise that could jeopardize public health or welfare.

Geothermal developers on NFS lands are subject to BLM leasing regulations. These mandate that noise at one-half mile—or at the lease boundary, if closer—from a major geothermal operation shall not exceed 65 A-weighted decibels (dBA; Federal Geothermal Resources Operational Order Number 4).

An understanding of current noise conditions in the project area is derived from a mix of noise measurements and modeled calculations. For example, geospatial models of the ambient sound level in the VCNP predict summer daytime median (L_{50}) sound levels ranging from approximately 30 to 32 dBA[16]. Noise measurements were taken at the El Cajete Pumice Mine in the JNRA south of the VCNP; normal background noise levels were measured at less than 40 dBA and up to 70 dBA, with a strong breeze in the surrounding pine forest. Vehicle noise on NM 4 was measured at 50 to 60 dBA from a distance of approximately 200 feet. Noise levels at oil and gas wells operating in the SFNF have also been measured. Gas-fueled pump-jacks registered at 55 to 60 dBA, at a distance of 20 feet from their spark arresters, and gas compressors registered at 55 to 70 dBA, at a distance of approximately 80 feet.[17]

3.20.2 Environmental Consequences

3.20.2.1 Scoping Comments on Resource

The following issue specific to noise was identified during the public scoping period:

- What are the impacts of increased noise in the project area?

3.20.2.2 How Resource Impacts Were Evaluated

Method

The method for the noise impact analysis is incorporated by reference from the noise section of the 2008 Geothermal PEIS.

[16] Randy Stanley, Natural Sounds and Night Skies Coordinator, National Park Service, personal communication with Forest Service. April 28, 2016.
[17] Larry Gore, Geologist, Forest Service, personal communication with Drew Vankat, EMPSi. February 10, 2016.

Indicators

Impact criteria for noise are incorporated by reference from the noise section of the 2008 Geothermal PEIS. More specifically, the analysis discusses potential noise levels and compares them to those set by the Federal Geothermal Resources Operational Order Number 4. This mandates that noise levels must be 65 dBA or less at the geothermal lease boundary, or 0.5 mile from the source, whichever is greater.

Assumptions

This analysis assumes the following:

- Future analysis for site-specific projects would identify the presence of sensitive noise receptors, such as residences or schools, in the vicinity of the proposed well drilling or geothermal plant activities.
- Noise levels for the specific activities would be assessed to determine their compliance with applicable noise guidelines, and measures to reduce noise impacts would be identified, if necessary.

3.20.2.3 Common Impacts Associated with Geothermal Development

Noise levels measured at geothermal power plants and wells can provide insight into the type and severity of impacts expected in the project area. In support of an EIS for the proposed Casa Diablo IV project near Bishop, California, Leiken (2011) measured average noise levels at the Galena-3 binary power plant near Reno, Nevada (**Table 3-33**).

Table 3-33. Observed and Calculated Noise Levels for Geothermal Power Plants, Production Wells, and Drill Rigs

Distance	Binary Power Plant	Production Well	Drill Rig
150 feet	71.5 dBA[1]	54.8 dBA[2]	69.1 dBA[2]
400 feet	64.5 dBA[1]	46.3 dBA[2]	60.6 dBA[1]
1,320 feet	54.0 dBA[1]	35.6 dBA[1]	50.2 dBA[2]

Source: Leiken 2011; Sengpielaudio 2016

[1] Observed or calculated average noise levels from Leiken 2011

[2] Calculated noise levels from Sengpielaudio 2016

Doubling the distance from the source of a sound decreases sound levels by 6 dBA. Using this formula, estimated sound levels at different distances can be calculated. Based on field measurements and calculated estimates, noise levels from binary power plants would only exceed the limit of 65 dBA established in Federal Geothermal Resources Operational Order Number 4 at distances of less than 400 feet. Production wells would exceed this limit at distances of less than 69 feet, and drill rigs would exceed this limit at distances of less than 241 feet. These distances are estimates, as vegetation, topography, and other site-specific factors could affect sound levels.

Noise impacts could also occur during the exploration stage of development; however, these impacts would generally be less than noise levels generated during drilling operations and utilization.

3.20.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. Measures to minimize noise related impacts (as identified above under *Common Impacts Associated with Geothermal Development*) would be considered in these separate NEPA analyses.

3.20.2.5 Impacts Under Alternative 2

Since leases are not issued on lands that also contain sensitive receptors, such as residences, schools, or hospitals, the maximum noise potentially experienced by such a receptor would be 65 dBA. This indirect impact from subsequent development would occur only if the receptor is next to the lease boundary or within 400 feet of a power plant. Due to the highly rural and unpopulated nature of lands in the decision area, it is unlikely that any sensitive receptors would be this close to noise-emitting geothermal equipment or activities.

3.20.2.6 Impacts Under Alternative 3

There would be no lands available for leasing in the project area and no noise impacts from subsequent geothermal exploration and drilling.

3.20.2.7 Impacts Under Alternative 4

Impacts would be similar to those described under Alternative 2, because the same level of disturbance, the same number of wells, and the same number of power plants are expected.

3.20.2.8 Cumulative Impacts

The region of influence for noise is the project area and adjacent landscapes. Past, present, and reasonably foreseeable future noise-producing projects are pumice mine operation and expansion and mechanical vegetation treatments. Cumulative impacts on noise could occur if these activities were close to geothermal development activities and sensitive receptors.

Geothermal development could potentially affect adjacent landscapes, including the VCNP, under Alternatives 1, 2, and 4. As shown in Table 3-X, Stipulations and Closures within a 1- and 2-mile Buffer of NPS Lands for Action Alternatives, under Alternative 2 there would be no lands open to geothermal leasing, subject to standard lease terms and conditions, within a 2-mile buffer of NPS lands. Under Alternative 4, approximately 400 acres would be open to leasing subject to standard lease terms and conditions within 2 miles of NPS lands. Under both alternatives, geothermal development could potentially occur within 2 miles of NPS lands, resulting in increased noise levels. There would be a greater potential for development near NPS lands under Alternative 4, as more acres would be open subject to standard lease terms and conditions near the VCNP boundary. However, implementing BMPs as described in Appendix C (such as sound control devices, adequate mufflers, and adequate equipment maintenance) would reduce these impacts from increased noise levels on NPS lands.

3.21 Transportation and Access

3.21.1 Affected Environment

A network of state highways and Forest Service roads serve the broader project area. Throughout the project area there are a range of single-lane and two-lane roads, with varying degrees of improvements and a broad range of users. The 2012 Record of Decision for the SFNF Travel Management Plan EIS provides a comprehensive summary of travel management issues and decisions on the SFNF (Forest Service 2012).

3.21.1.1 State Highways

There are three main state highways in the project area: NM 4, NM 126, and NM 96. For NM 4 the 2014 annual average daily traffic (AADT) was 3,198 vehicles (New Mexico Department of Transportation [NMDOT] 2014). For NM 126, the 2014 AADT was 2,700 vehicles (NMDOT 2014), and for NM 96, the 2014 AADT was 1,238 vehicles (NMDOT 2014). These state highways are two-lane roads with narrow shoulders, and they traverse the forested and mountainous terrain typical of this part of northern New Mexico.

The Jemez Mountain Trail National Scenic Byway follows NM 4 for 21.8 miles in the project area (Forest Service GIS 2015). NM 4 is a popular one-day loop drive, connecting Albuquerque with Los Alamos and Santa Fe, and is the main access to the developed campgrounds, picnic areas, and trailheads. NM 4 also travels directly through Jemez Pueblo and is often highly congested during the summer and fall, with tourists, recreation vehicles, and day visitors. NM 126 is also in the project area, for a total of 6.2 miles (Forest Service GIS 2015). NM 126 provides access to Fenton Lake and Cuba, located west of the project area. NM 96, along the northern project boundary for 10.4 miles, connects Abiquiu with Coyote, Gallina, Regina, and other towns and villages to the west of the project area (Forest Service GIS 2015). It is less popular with tourists.

3.21.1.2 SFNF Roads and Trails

The SFNF has implemented the Travel Management Rule that requires all National Forests and Grasslands to designate a system of roads, trails, and areas for motorized use and to prohibit all motor vehicle use off the designated system.

To address concerns about the impacts of unmanaged off-highway vehicles, the Forest Service published final travel management regulations for motor vehicle use on National Forests and Grasslands on November 9, 2005. The Travel Management Rule “provides for a system of NFS roads, NFS trails, and areas on NFS lands that are designated for motor vehicle use. After these roads, trails, and areas are designated, motor vehicle use, including the class of vehicle and time of year, not in accordance with these designations is prohibited.”

On the SFNF, complying with the Travel Management Rule means the following:

- No cross-country motorized travel except in designated areas
- Identification of roads and trails that are open for motorized use
- Designation of the limited use of motor vehicles within a specified distance of certain designated routes and, such as within specified periods, solely for the purposes of dispersed camping or retrieval of a big game animal by an individual who has legally killed that animal
- A Forest Plan that reflects these management classifications and is consistent with the Travel Management Rule (Forest Service 2012)

The 2015 SFNF Motor Vehicle Use Maps provide a comprehensive overview of system roads and trails on the SFNF. These maps show which roads and trails are open to motor vehicle travel, what type of vehicle they are open to, and what season they are open. Within the project area, roads and trails are as follows (Forest Service GIS 2015):

- Miles of paved main roads—19
- Miles of dirt main roads—125
- Miles of dirt roads—908
- Miles of motorized trails—74

Forest Road 376 travels through the most used motor vehicle-dispersed recreation area on the SFNF. An estimated 97,000 to 110,000 people travel on this road every year. Forest Road 10 is another highly used motor vehicle recreation corridor; 93,000 to 107,000 people travel through and recreate along this road every year. Forest Road 10 provides primary access to other dispersed recreation areas along Forest Roads 266, 270, and 269. The dispersed camping corridor along Forest Road 144 serves as an overflow area for the Forest Road 376 recreation area when it is full (Forest Service 2015b). Other Forest roads in the project area also experience high-volume visitation during the peak summer season.

3.21.2 Environmental Consequences

3.21.2.1 Scoping Comments on Resource

The following issues specific to transportation and access were identified during the public scoping period:

- How would increased traffic affect residents, visitors, and other Forest users?
- What would the impacts be on road conditions and adjacent buildings as a result of increased traffic?

3.21.2.2 How Resource Impacts Were Evaluated

Method

Information from the National Visitor Use Monitoring surveys (NVUM 2013), the SFNF Travel Management EIS and Record of Decision (Forest Service 2012), SFNF GIS (Forest Service GIS 2015), and traffic counts from the NMDOT (2014) were used to estimate the number of visitors to the area, the travel management issues on the Forest, areas of greatest use in the project area, and the overall issues that would be encountered under the analyzed alternatives.

Indicators

Potential impacts on transportation and access could occur if reasonably foreseeable future actions were to have the following impacts:

- Change traffic patterns or volume
- Change access to public or private roads

Assumptions

This analysis assumes the following:

- Making land potentially available to geothermal leasing, as included under Alternatives 1, 2, and 4, would not impact transportation or access; however, impacts could occur if applicants propose exploration or production. These impacts would be considered in future site-specific analyses under NEPA.

- Potential future geothermal activities could improve motorized access, with a possible increase in traffic and congestion from large construction vehicles operating during exploration and development.

3.21.2.3 Common Impacts Associated with Geothermal Development

Due to the inability to predict the location, scope, scale, and timing of future development, the following impact analysis provides a general description of common impacts on transportation and access from geothermal development. The information presented in the Development section of the 2008 Geothermal PEIS may also be referenced (BLM and Forest Service 2008).

If the geothermal resources in the project area are explored or used, there could be impacts on traffic and access along the primary routes in the project area (NM 4, NM 96, and NM 126). This would be due to additional vehicles, such as large trucks, drilling rigs, cranes, construction trailers, or other long-wheelbase vehicles.

Impacts could include increased congestion. This is because the use of these large vehicles with limited turning radii and potentially heavy loads that make acceleration difficult would likely slow other traffic in the steep, narrow roads with limited sight distance that are typical of the project area. These potential increases in congestion and traffic would mostly be temporary and limited to exploration and development, in contrast to the operational phase of geothermal development; this requires fewer large vehicles and would result in minor or negligible impacts on transportation or access. Such measures as traffic control plans, signage, and TLs could help to mitigate the temporary impacts on traffic and access during exploration and development (see Appendix C).

If the geothermal resources in the project area were explored or used, there could be impacts from the development of new roads or improvements to existing roads. The RFDS (BLM 2015) estimates that under the exploration phase, approximately 10 miles of current 12-foot-wide roads may be widened by up to 8 feet—for a total road width of 20 feet—to accommodate large drill rigs and tractor-trailers. These existing two-track roads vary in condition, but generally would require the aforementioned widening, along with grading and other minor improvements to accommodate seismic activities or exploratory drilling. Fewer vehicles and trips would be involved with exploratory activities, compared with development and utilization (BLM 2015).

During the development and utilization phases, the BLM (2015) estimates that the 10 miles of roads used during exploration may be widened by an additional 2 feet—for a total road width of 22 feet. This is because access roads would have to be at a higher standard than for gradient-well drilling: the drill rig for a full-diameter well is transported to the site by tractor-trailer. The number of trips for both heavy and light vehicles would be significantly greater than under the exploration phase. Transporting the drill rig and ancillary equipment to the site may require approximately 15 to 20 trips by full-sized tractor-trailers; the same number would be required to demobilize the rig. The size of the material-supply trucks and water trucks would necessarily be larger than for a temperature-gradient well, and the number of trips would be proportionally greater, given the greater well depth. A full-diameter drilling operation typically has from 10 to 15 people on-site at all times, with more coming and going periodically with equipment and supplies, which may increase traffic and congestion (BLM 2015).

In addition, there would be impacts from the construction of new temporary roads associated with development and utilization phases in the project area. The temporary roads would be adequate for exploration and development equipment and trucks to get from geothermal sites to a landing or main road and could be decommissioned after use. A temporary road is one that is authorized by contract, special use permit, lease, or other written authorization that is not an NFS road and that is not included in an NFS transportation atlas. Any temporary roads would not require an amendment to the Travel Management Plan.

3.21.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations. Impacts would be similar to those identified under *Common Impacts Associate with Geothermal Development*, such as temporary increases in congestion and traffic limited to the use of large, long-wheelbase construction vehicles in the exploration and development phases. Under Alternative 1, there would be no amendment to the Travel Management Plan.

3.21.2.5 Impacts Under Alternative 2

Direct and indirect impacts would be the same as those described under Alternative 1. However, implementing closures and stipulations may limit the volume of traffic in those areas. TLs imposed on drilling operations and construction would reduce the volume of traffic between March 1 to September 30, compared to Alternative 1.

3.21.2.6 Impacts Under Alternative 3

Under Alternative 3, the SFNF would amend the Forest Plan to implement discretionary closures to geothermal leasing on all lands in the project area not already closed to leasing. There would be no direct or indirect impacts on transportation or access, compared to Alternative 1.

3.21.2.7 Impacts Under Alternative 4

Direct and indirect impacts would be the same as those described under Alternative 2.

3.21.2.8 Cumulative Impacts

Consenting to the issue a geothermal lease has no direct impact on the environment (40 CFR, Subpart 1508.8[a]); however, it is a commitment of the resource for potential future exploration, drilling operations and development, utilization, and reclamation and abandonment. These would be subject to environmental review under NEPA and project-specific permitting from the BLM and the SFNF. However, any future development of geothermal resources may result in impacts, whether significant or not. It is reasonable, therefore, to foresee that on-the-ground impacts on transportation and access may occur if the Forest Service consents to leasing and the BLM issues geothermal leases. Those impacts would not occur, however, until some point in the future, following several decision stages.

Past and present activities that have had cumulative impacts on transportation and access are mining, ranching, timber cutting, road building, road decommissioning, off-road vehicle riding, developing the LANL, and implementing the travel management plan. In addition, the 2014 transfer of Valles Caldera to a National Preserve under the management of the NPS has increased access, visitor days, and overall traffic on NM 4 and portions of the project area next to the caldera.

Reasonably foreseeable future actions are the proposed South Pit Pumice Mine Expansion, the Duran 2010 Pumice Mine, and the Valles Caldera nomination under the Geothermal Steam Act of 1970 (30 USC, Section 1019). The two pumice mines on the Jemez Ranger District could have a minor cumulative impact on transportation and access. Further, if the VCNP is designated as a significant thermal feature under the Geothermal Steam Act, development in areas near to the caldera, or those with hydrological connections, may not be leased; this would reduce potential indirect impacts on transportation and access, such as increased congestion. Other reasonably foreseeable actions could include potential fire management activities, timber sales, mineral leases, and transmission lines.

Incremental cumulative impacts would not be anticipated under Alternative 3, because the project area would be closed to geothermal leasing. Under Alternatives 1, 2, and 4, incremental cumulative impacts on transportation and access would increase traffic and congestion. However, these would be temporary impacts associated with exploration and development.

3.22 Climate Change

3.22.1 Affected Environment

Climate

Climate is defined as the generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate is both a driving force and a limiting factor for biological, ecological, and hydrologic processes, as well as for resource management of public lands.

The climate of the project area is generally mild. The summer and fall are characterized by warm daytime temperatures and cold nights. While the winter is relatively mild, snow depths may average eight to ten feet. In the summer, the climate is abundant in sunshine, with large variations between daytime and nighttime temperatures. Peak precipitation occurs in late summer and early fall, when moisture from the Gulf of Mexico moves into the region.

Table 3-34, below, shows monthly climate normal data from 1981 to 2010 for select towns within the buffer zones of the project area. Climate normals are three-decade averages of climatological variables produced by the National Oceanic and Atmospheric Administration, National Climatic Data Center, every ten years. Monthly summary tables of these data, along with average annual snowfall, were obtained from the Western Regional Climate Center.

Table 3-34. Average Temperatures and Precipitation in the Project Area (1981-2010)

Location	Average Maximum Temperature (°F)			Average Minimum Temperature (°F)			Average Precipitation (in inches)			Average Snow in Inches
	Jan	Jul	Annual	Jan	Aug	Annual	June	Aug	Annual	
Los Alamos	39.6	81.1	60.4	18.6	53.3	36.3	1.56	3.42	19.03	53.2
Santa Fe	43.8	86.2	65.4	18.3	54.0	36.0	1.25	2.23	14.19	21.0

Source: WRCC 2014

Climate Change

Climate change is an identifiable change in climate over time due to natural internal processes and variability or as a result of human activity (IPCC 2014). The United Nations Framework Convention on Climate Change further defines climate change as attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is natural climate variability observed over comparable periods (United Nations 1992).

According to the most recent assessment from the Intergovernmental Panel on Climate Change (IPCC), humans are the primary cause of climate change through emissions of GHGs. The earth has a natural greenhouse impact, wherein naturally occurring gases, such as water vapor, carbon dioxide, methane, and nitrous oxide, absorb and retain heat. Without the natural greenhouse impact, the earth would be approximately 60°F cooler. Climate change is caused in part by the increase in GHGs in the atmosphere beyond naturally occurring levels. Over time the amount of energy sent from the sun to the earth's surface should be approximately the same as the amount of energy radiated back into space, leaving the temperature of the earth's surface roughly constant. Increased levels of GHGs trap more heat in the atmosphere and result in average overall warming of temperatures over time.

From 1983 to 2012, the northern hemisphere experienced what is likely the warmest 30-year period in the last 1,400 years, and global temperatures have increased 1.53ºF since 1880 (IPCC 2014). A climate change vulnerability assessment for biodiversity in New Mexico identified the following climate trends (Enquist and Gori 2008):

- Mean annual temperatures have risen across New Mexico and the southwestern United States since the early twentieth century. Relative to a 1961 to 1990 baseline, both the 1991 to 2005 and 2000 to 2005 periods show temperature increases in over 95 percent of the geographical area of New Mexico. The magnitude of warming varied across the state, with the greatest warming in northwestern, central, and southwestern New Mexico.
- In New Mexico, mean annual temperatures increased 0.6°F per decade, with a 1.8°F overall change since 1976, when averaged across the state's eight climate divisions. Mean winter temperatures are most responsible for this rise, yet springtime temperatures have also risen.
- Precipitation changes vary across New Mexico, with 54 percent of the state tending toward wetter conditions, 41 percent toward drier conditions, and 5 percent showing no change during the 1991 to 2005 period, compared to 1961 to 1990 baseline conditions.

Climate change has potentially disruptive consequences for agriculture, water supply, transportation, coastal communities, the economy, energy, ecosystems, and national security. Observed climate change has impacted natural and human systems, regardless of its cause, underscoring the sensitivity of natural and human systems to changing climate (IPCC 2014). In New Mexico, climate change is likely to exacerbate the impacts of natural and altered disturbance regimes, including wildfire, insect outbreaks, flooding, and erosion, across all habitat types and may prompt abrupt ecological changes. This is particularly true in such ecosystems as grasslands, riparian areas, and forests, where the impacts of past management and land use change are substantial (Enquist and Gori 2008).

Mid- to high-elevation forests and woodlands have experienced the highest levels of climate change effects since the late twentieth century, particularly in terms of mean temperature increases. The forests and woodlands in northwestern New Mexico have been subjected to consistently warmer and drier conditions. Elevated moisture stress in forests and woodlands of the southwestern United States has been shown to amplify the impacts of ecological disturbance regimes, such as insect outbreaks and fire, in addition to increasing the risk of large-scale forest diebacks. These disturbances are expected to increase under the warmer and drier conditions that most climate models predict for twenty-first century climate in the region (Enquist and Gori 2008).

Greenhouse Gases

GHGs are compounds that contribute to climate change by trapping heat in the atmosphere. They absorb infrared radiation and radiate a portion of that radiation back to the earth's surface, thus trapping heat and warming the atmosphere. The most important naturally occurring GHG compounds are carbon dioxide (CO_2), methane, nitrous oxide, ozone, and water vapor. CO_2, methane, and nitrous oxide are produced naturally by the following processes:

- Respiration and other physiological processes of plants, animals, and microorganisms
- Decomposition of organic matter
- Volcanic and geothermal activity
- Naturally occurring wildfires
- Natural chemical reactions in soil and water

Ozone is not released directly by natural sources but forms during complex chemical reactions in the atmosphere among organic compounds and nitrogen oxides in the presence of ultraviolet radiation. While water vapor is a strong GHG, its concentration in the atmosphere is primarily a result and not a cause of changes in surface and lower atmospheric temperature conditions.

Although naturally present in the atmosphere, concentrations of CO_2, methane, and nitrous oxide are also produced by industrial processes, transportation technology, urban development, agriculture, and other human activity. Globally, atmospheric CO_2 concentrations have increased from an estimated 277 parts per million before 1750 to approximately 395 parts per million in 2013 (Global Carbon Project 2014).

In the United States, GHG emissions come mostly from energy use. Such emissions result from combustion of fossil fuels used for electricity generation, transportation, industry, heating, and other needs. In 2009, the electric power sector was the largest source, accounting for 40 percent of all energy-related CO_2 emissions; the transportation sector was the second-largest source, at 34 percent of total emissions (EIA 2011).

The EPA estimated that national GHG emissions in 2014 (the most recent year for which national data has been tabulated) totaled 6,873 million metric tons of carbon dioxide equivalents (CO_2e; a measure that accounts for the global warming potential of the different GHGs; EPA 2015).

The most recently available comprehensive inventory of statewide GHG emissions for New Mexico occurred in 2007. It showed gross GHG emissions of 76.2 million metric tons of CO_2e (NMED 2010). This state-wide inventory was 1.02 percent of total US emissions for that same year (7,480 million metric tons of CO_2e).

Large emitters are required to report their GHG emissions to the EPA annually. Reported sources in Rio Arriba County were nine petroleum and natural gas systems, which emitted 405,735 metric tons of CO_2e. Reported sources in Sandoval County include two landfills, a wallboard plant, and an electronics manufacturing facility that emitted 206,035 metric tons of CO_2e (EPA 2014).

3.22.2 Environmental Consequences

3.22.2.1 Scoping Comments on Resource

The following issues specific to climate change were identified during the public scoping period:

- How would the SFNF address climate change and GHG emissions from geothermal leasing?
- Would geothermal leasing affect regional weather conditions?

3.22.2.2 How Resource Impacts Were Evaluated

Method

The method for climate change compares estimated GHG emissions from well drilling, the primary source of temporary emissions from geothermal development, against national and state GHG emission levels and against the indicator described below. The analysis also compares GHG emissions associated with geothermal power production against GHG emissions from other sources of energy generation.

Indicators

On September 22, 2009, the EPA released final regulations for a Greenhouse Gas Monitoring Rule (see 74 *Federal Register* 56260). The reporting rule requires suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions to submit annual reports to the EPA. As there are no Clean Air Act significance thresholds for evaluating GHGs, this analysis compares likely GHG emissions from each alternative against the Greenhouse Gas Monitoring Rule.

Assumptions

The analysis makes the following assumption:

- BMPs, such as those identified in Appendix C, would be applied at the BLM permitting level to minimize impacts on air quality from exploration, drilling operations, utilization, and reclamation and abandonment. Minimization of equipment-related air quality impacts also would minimize GHG emissions from this equipment.
- Based on existing temperature gradient data, binary cycle power plants (which operate at lower temperatures than flash steam plants or dry steam plants) are the most likely technology that would be developed in the project area. Therefore, this analysis does not assess the potential impacts of flash steam or dry steam geothermal power plants. Binary plants are closed-loop systems and do not emit GHGs during their operation. For this reason, only GHG emissions from exploration and development are evaluated.
- Binary plants would use air cooling rather than wet cooling.
- There is a correlation between global concentrations of GHGs and climate change. However, it is not currently possible to link projected GHG emissions associated with any particular activity to specific environmental impacts at a specific site or location.

3.22.2.3 Common Impacts Associated with Geothermal Development

The information on climate change presented in the Common Impacts on Air Quality and Atmospheric Values Associated with Geothermal Development section of the PEIS is incorporated here by reference (this section of the PEIS also addresses climate change and GHGs). Leasing would have no direct impacts related to climate change or emissions of GHGs.

Temporary emissions of CO_2 and methane from equipment use would occur during all phases of geothermal development. Sources of these temporary GHG emissions are vehicles, truck traffic, and construction equipment required for exploration, well drilling, and power plant construction.

Exploration

Exploration would result in exhaust-related CO_2 emissions and much smaller amounts of methane from vehicles and construction and drilling equipment. Sources of emissions are the following:

- Gas- and diesel-powered construction equipment for exploration road development
- Drill rigs and auxiliary equipment to develop temperature gradient wells and slim wells
- Tractor trailers to bring in and move out construction and drilling equipment
- Water trucks for dust suppression during road construction and to bring in water for mixing drilling fluids during well development
- Delivery trucks for supplies
- Commute vehicles for road construction and drill rig personnel

Table 3-35 provides estimated CO_2 emissions from geothermal development under the RFDS. The time frame for geothermal exploration is one to five years.

Table 3-35. Geothermal Development Exploration Well Carbon Dioxide Emissions

Activity	CO_2 (tons) [1]
On-road vehicle exhaust (tons per well)	10
Unpaved road dust (tons per well)	0
Paved road dust (tons/well)	0
Drill rig and auxiliary equipment (tons per well)	82
Total (tons per well)	**92**
Total[2] (tons per RFDS [20 wells])	**1,840**

Source: Forest Service 2016d

[1]Assumptions for equipment use, vehicle miles traveled, and drilling times and durations, along with emission spreadsheet tables, are provided in the Air Quality Technical Report (Forest Service 2016d).

[2]Emissions from vehicle travel would likely be less under the full RFDS, as drill rig equipment and other construction equipment would likely be moved from well site to well site, resulting in fewer miles traveled than calculated for a single well development.

In addition to the drilling-related CO_2 emissions shown in **Table 3-35**, on-road construction equipment for road development would produce CO_2 emissions and much smaller amounts of methane. BMPs, such as those identified in Appendix C, would be applied at the permit level. Measures to mitigate equipment exhaust emissions, if applied, would also reduce CO_2 emissions.

Temperature gradient wells do not typically encounter the geothermal resource; therefore, no release of naturally occurring non-condensable gases, comprised mostly of carbon dioxide, would occur. Slim wells do encounter the geothermal resource and thus have the potential to release CO_2 during development.

Exploration would disturb approximately 27 acres, primarily for exploration road development. Removing vegetation and disturbing soil releases the soil organic carbon and the carbon stored in the vegetation.

Development Drilling and Utilization

Development drilling and utilization would result in exhaust-related CO_2 emissions and much smaller amounts of methane from vehicles and construction and drilling equipment. Sources of emissions are the following:

- Gas- and diesel-powered construction equipment for well pad, transmission line, pipeline, road, and power plant construction
- Drill rigs and auxiliary equipment to develop production and injection wells
- Tractor trailers to bring in and move out construction and drilling equipment and materials to construct the power plants
- Water trucks for dust suppression during road construction and to bring in water for mixing drilling fluids during well development
- Delivery trucks for supplies
- Commute vehicles for construction and drill rig personnel

Well drilling has the potential to release non-condensable gases, primarily CO_2. Non-condensable gases would be emitted during flow testing and would last until the well is shut in or connected to the pipeline.

Table 3-36 depicts potential CO_2 emissions associated with geothermal development. The time frame for geothermal exploration is two to ten years.

Table 3-36. Geothermal Development Well Drilling Carbon Dioxide Emissions

Activity	CO_2 (tons) [1]
On-road vehicle exhaust (tons per well)	38
Unpaved road dust (tons per well)	0
Paved road dust (tons per well)	0
Drill rig and auxiliary equipment (tons per well)	802
Total (tons per well)	**840**
Total (tons per 6 wells, or 1 power plant)	**5,040**
Total[2] (tons per RFDS [30 wells])	**25,200**

Source: Forest Service 2016d

[1]Assumptions for equipment use, vehicle miles traveled, and drilling times and durations, along with emission spreadsheet tables, are provided in the Air Quality Technical Report.

[2]Emissions from vehicle travel would likely be less under the full RFDS, as drill rig equipment and other construction equipment would likely be moved from well site to well site, resulting in fewer miles traveled than calculated for a single well development.

In addition to the development drilling-related emissions shown in **Table 3-36**, the following construction activities would produce CO_2 emissions and much smaller amounts of methane:

- Non-road construction equipment emissions for well pad, transmission line, pipeline, road, and power plant construction
- On-road vehicle equipment emissions from material and equipment deliveries, water trucks, concrete trucks, and construction personnel commute vehicles

As described under *Exploration*, BMPs, such as those identified in Appendix C, would be applied at the permit level. Measures to mitigate equipment exhaust emissions, if applied, would also reduce CO_2 emissions.

In addition to equipment and vehicle emissions, well drilling has the potential to release non-condensable gases. The amount and ratio of the constituents in the geothermal resource varies by geology, with carbon dioxide generally comprising over 95 percent of the non-condensable gases. Emissions of non-condensable gases would occur during flow testing and would continue until the well is shut in or connected to the pipeline.

Development and utilization would disturb approximately 647 acres for well pads, transmission lines, pipelines, roads, and power plant facilities. Removing vegetation and disturbing soil releases the soil organic carbon and the carbon stored in the vegetation.

Power Plant Operation

Under the RFDS, five 25-megawatt geothermal binary cycle power plants would operate for a period of 30 to 50 years. The RFDS estimates that each plant would employ 9 shift workers and up to 12 additional workers per day. CO_2 emissions would be limited primarily to vehicle and maintenance equipment emissions, including vehicle commute traffic, delivery traffic, and on-site maintenance truck and equipment use.

Operating a closed binary cycle geothermal power plant does not emit CO_2, except from well venting during maintenance and potentially if there are leaks. The plants would use air cooling and therefore would not emit steam into the environment. Development of the power plants would have an indirect impact on GHG emissions if the power produced by the plants were to displace electricity generated by conventional sources of electricity. Geothermal power production creates less CO_2 per kilowatt-hour of electricity produced than burning fossil fuels. It would have a positive net impact on CO_2 emissions if used in place of fossil fuel extraction. Compared to coal and natural gas, geothermal energy has a smaller carbon footprint and lower gaseous emissions (Matek 2013).

Table 3-37, below, compares CO_2 emissions for a composite of geothermal power plant technology versus fossil fuel plants. As shown, geothermal plants emit significantly less CO_2 (Bloomfield et al. 2003). Because the geothermal technology used in the project area would be air-cooled binary plants, no CO_2 would be emitted from operation of the plants.

Table 3-37. Comparison of Geothermal and Fossil Fuel Carbon Dioxide Emissions

	Geothermal	Coal	Petroleum	Natural Gas
Emissions (pounds of CO_2 per kilowatt-hour)	0.2	2.095	1.969	1.321

Source: Bloomfield et al. 2003

3.22.2.4 Impacts Under Alternative 1

Under Alternative 1, the SFNF would not make an availability determination for geothermal leasing in the project area. Geothermal lease applications and nominations would continue to be processed; however, they would be evaluated on a case-by-case basis under separate NEPA analysis, in accordance with the Forest Plan and existing laws and regulations.

Alternative 1 would have no direct climate change impacts.

Indirect impacts would include the production of GHG emissions during all phases of geothermal development, including construction and well drilling. GHGs would be produced through the combustion of fuels used by construction equipment and construction-related vehicles. GHGs would also be emitted during well drilling as the CO_2 is released from the geothermal resource itself. Carbon would be released from the removal of vegetation and disturbance of soils on approximately 760 total acres. Any BMPs or measures designed to reduce equipment and vehicle exhaust emissions to minimize impacts on air quality would also reduce GHG emissions.

As shown under *Common Impacts Associated with Geothermal Development*, well drilling during exploration would emit an estimated 1,840 tons of CO_2 under the RFDS (20 temperature gradient and slim wells), while well drilling under exploration would emit an estimated 25,200 tons of CO_2 under the RFDS (30 production wells). These emissions would occur over the life of the exploration phase (one to five years) and development phase (two to ten years); thus these activities would emit less than the referenced 25,000 metric tons of GHG per year under the EPA's GHG Monitoring Rule, which is used as an indicator in this analysis. They would also represent less than 1 percent of national and state emission levels.

GHG emissions associated with the operation of geothermal power plants would include commute traffic, maintenance traffic, and truck deliveries and potential releases of CO_2 during maintenance. GHG emissions from each power plant would be expected to be well below the 25,000 metric tons per year reporting limit under the Greenhouse Gas Monitoring Rule.

As described under *Common Impacts Associated with Geothermal Development*, geothermal power plant development could have an indirect impact, if power produced by the geothermal plant were to displace electricity generated by conventional fossil fuel sources of electricity and thus offset CO_2 emissions that would otherwise be provided by fossil fuel-produced electricity.

3.22.2.5 Impacts Under Alternative 2

Indirect impacts would be the same as those described for Alternative 1.

3.22.2.6 Impacts Under Alternative 3

Under Alternative 3, there would be no geothermal development and no emissions of GHGs.

3.22.2.7 Impacts Under Alternative 4

Indirect impacts would be similar to those described for Alternative 1.

3.22.2.8 Cumulative Impacts

The cumulative impacts analysis region of influence for GHG emissions is northern New Mexico. Past and present actions and events in this analysis area have directly emitted GHGs and caused carbon to be released from soils and vegetation. Past and present actions and conditions that have contributed GHGs to the atmosphere are urban development (population increases spurring development), mineral development, energy production, fossil fuel burning (primarily transportation-related use), and wildfire. These sources will continue to emit GHGs in the future. Reasonably foreseeable future actions in the immediate project area from vegetation and water resources management, described in **Section 3.3.4**, would temporarily emit GHGs from vehicles and equipment; surface disturbance also would release carbon during vegetation removal and soil disturbance.

Current scientific technology makes it difficult to link a specific action to a specific climate change-related impact. Emissions of GHGs from construction under Alternatives 1, 2, and 4 would be small in the context of broader emissions. However, over the long term, these actions, in combination with other GHG-emitting actions, do contribute to total global emission levels. These, in turn, could contribute to future long-term, anticipated climate changes to a small degree. Overall, the contribution of geothermal development under Alternatives 1, 2, and 4 would be a very small portion of the total from other sources of a regional and global nature. In addition, GHG production would be temporary, because the plants would not emit GHGs. Therefore, GHG emissions under Alternatives 1, 2, and 4 would not be cumulatively significant.

Alternatives 1, 2, and 4 would result in five 25-MW binary geothermal plants being brought online, which would have the potential to reduce GHG emissions from other sources of nonrenewable energy.

3.23 Short-Term Uses and Long-Term Productivity

NEPA requires consideration of "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR, Subpart 1502.16). As declared by Congress, this includes using all practicable means and measures, such as financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which humans and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

For this EIS, short term refers to the steps needed to develop a geothermal resource (exploration, drilling, testing, and construction). Long term refers primarily to the 15-year time frame described within the RFDS.

The exploration and testing phase of a geothermal project is designed to determine the nature and extent of the geothermal resource, including boundaries, controls on permeability, temperature distribution, and fluid flow paths. Generally, this phase lasts one to five years. Where such exploration proves unsuccessful, these lands would not be used for subsequent development and production; instead they would be restored as much as possible to their original condition on completion of exploration and testing.

If geothermal activities progress beyond the exploration and testing phase into the development and production phases, the lands could be affected to a greater extent. The short-term uses of the environment associated with anticipated future actions—exploration, drilling, land clearing, plant construction, operation, maintenance, and plugging and final reclamation, as detailed in the RFDS—consistent with implementation of Alternatives 1, 2, and 4, include impacts on the natural and human environment, as detailed in each resource section of this chapter. These short-term impacts can be compared to the long-term productivity associated with long-term renewable energy production. Under Alternative 3, all lands in the project area would be closed to leasing, and there would be short-term uses or long-term productivity associated with geothermal development.

Over the long term, while geothermal plants are in production, low-cost and renewable energy would be generated. Geothermal power production creates less CO_2 per kilowatt-hour of electricity produced than burning fossil fuels. Compared to coal and natural gas, geothermal energy has a smaller carbon footprint and lower gaseous emissions (Matek 2013). Therefore, geothermal energy development would offset the use of irretrievable resources, such as coal and oil, which would reduce GHG emissions.

In addition, while in production, each plant would provide employment opportunities for citizens of surrounding communities, and energy sales would generate revenue for Rio Arriba and Sandoval Counties.

3.24 Unavoidable Adverse Impacts

Consenting to geothermal leasing and the subsequent issuing of leases would not result in any unavoidable adverse impacts. These impacts would be assessed during the permitting process and on a site-specific basis. If geothermal leases were developed, adverse impacts would be expected. Because the RFDS anticipates development of leases under Alternatives 1, 2, and 4, the following impacts would be applicable to these alternatives:

- Long-term loss of vegetation, wildlife habitat, soil, and soil quality. The stipulations in the EIS would reduce these impacts as described under **Section 3.8**, Soil Resources, **Section 3.11**, Vegetation, **Section 3.12**, Fish and Wildlife, and **Section 3.13**, Threatened and Endangered Species and Special Status Species.
- Short-term and intermittent noise impacts from construction and maintenance as described under **Section 3.20**, Noise.
- Possible loss of recreation opportunities from energy infrastructure, although new roads could provide access for additional recreation opportunities, as described under **Section 3.4**, Land Use, Recreation, and Special Designations.
- Long-term visual impacts from power plants and infrastructure. The degree to which visual impacts would occur would vary by alternative, as described in **Section 3.17**, Visual Resources.

There would be no unavoidable adverse impacts under Alternative 3, as all lands in the project area would be closed to geothermal leasing.

3.25 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitments of resources associated with implementing the alternatives. Resources irreversibly or irretrievably committed by a proposed action are those used on a long-term or permanent basis. Irreversible resource commitments occur when there is unavoidable destruction of natural resources that could limit the range of potential uses of that particular environment. Irreversible commitments apply primarily to nonrenewable resources, such as cultural resources, and also to those resources that are renewable only over long periods, such as soil productivity or forest health. Irretrievable resource commitments occur when an action causes the use or consumption of a resource that is neither renewable nor recoverable for future use. Irretrievable commitments apply to loss of production, harvest, or use of natural resources. These include the use of nonrenewable resources such as metal, fuel, and other natural or cultural resources considered irretrievable, in that they would be used for the proposed action when they could have been conserved or used for other purposes.

No irreversible commitments of resources would result from the Forest Service providing consent to geothermal leasing. In addition, stipulations outlined under the action alternatives would be applicable to future phases of leasing and development, and lessees would be required to complete a site-specific NEPA analysis outlining their proposed action and alternatives and the direct and indirect impacts associated with their proposed action, before any occupancy and surface disturbance. Nevertheless, anticipated future development actions that may follow leasing consistent with implementation of any of the alternatives discussed in **Chapter 2** could result in a variety of irreversible and irretrievable commitments of resources, below.

3.25.1 Geologic Resources and Energy and Mineral Resources

The principal commitment of resources in implementing the proposed action would be the depletion of thermal energy and water from the geothermal reservoirs tapped for energy use. To minimize this impact, the super-hot water extracted from the subterranean geothermal reservoirs through production wells would be injected back into the reservoir for reheating and reuse. Over time, these resources (heat and water) could be depleted to the point that the power generating plant would no longer be economically productive.

3.25.2 Water Resources

Because of the large volume and long duration of geothermal fluid production, the production stage of resource development is likely to have the greatest potential for impact on hydrologic resources. These impacts could occur in terms of changes to the hydraulics of the geothermal and groundwater reservoirs and spent geothermal fluid disposal. The result could include a reduction in spring discharge rates and lowering of water levels in wells. Re-injecting spent geothermal fluids could also introduce low-quality fluids to groundwater pathways that discharge at springs or wells. This could also affect the quality of available water. Disposal of spent geothermal fluids on the surface could create large pools of low-quality water. Changes in spring flow and development of spent fluid-holding ponds could impact wetlands-supported ecosystems and habitats. As a result, hydrologic impacts associated with geothermal development could have secondary impacts in the plant and animal community supported by natural or created wetlands

3.25.3 Vegetation

Introduction of noxious weeds by construction and support vehicles into previously clean areas would be probable during all phases of geothermal development. The drilling and utilization phases would present the greatest opportunity for noxious weed introduction and proliferation. Once introduced, control or eradication of noxious weeds could be difficult.

3.25.4 Threatened and Endangered Species

Loss of any species is irretrievable. Protection of threatened, endangered, and special status species is governed by federal and state statute. To minimize the impacts on threatened, endangered, and special status species, lessees would be required to complete a site-specific NEPA analysis, outlining their proposed actions and alternatives, and the direct and indirect impacts of their proposed actions, on any threatened, endangered, and special status species before any occupancy and surface disturbance. Site-specific compliance with the ESA would occur at the time of development.

3.25.5 Visual Resources

Any changes in the characteristic landscape of the affected areas due to geothermal energy development could be visible for many years. Succession (change in habitat type over time, including the return of an area to its pre-development state after site reclamation/rehabilitation) in the project area is slow, due to generally low annual precipitation. Rehabilitation techniques could use nonindigenous plant species, thus changing the character of the area. The degree of contrast between a reclaimed project site and its untouched surroundings would vary by area, rehabilitation techniques, and the success of those techniques. All landscapes are unique in their own right, and any change or loss of scenic values is irretrievable. Those losses become more significant in areas of unique or outstanding scenic quality.

3.25.6 Hazardous Materials and Waste and Solid Waste

If handled improperly, hazardous materials and waste and solid waste have the potential to create irretrievable consequences. The transportation, storage, use, and disposal of hazardous materials and waste and solid waste are governed by federal and state statutes. To minimize the impacts of hazardous materials and waste and solid waste, lessees would be required to complete site-specific NEPA analyses, outlining their proposed actions and alternatives and the direct and indirect impacts of hazardous materials and waste and solid waste associated with their proposed actions before any occupancy and surface disturbance.

Chapter 4. Consultation and Coordination

4.1 Preparers and Contributors

The Forest Service consulted the individuals, federal, state, and local agencies, tribes, and other organizations below during the development of this environmental impact statement.

4.1.1 Interdisciplinary Team Members

Santa Fe National Forest Interdisciplinary Team Members

Team Member	Responsibility	Education	Years of Relevant Experience
Will Amy	Wildlife Program Manager	BS Natural Resource Sciences	17
Anne Baldwin	Supervisory Archeologist	BA Anthropology MA Cultural Anthropology	40
Christine Bishop	Rangeland Program Manager	BS Wildlife Biology MS Rangeland Ecology	12
Michael Bremer	Forest Archaeologist	BA Anthropology MA Anthropology	40
Mathew Chavez	Range Management Specialist	BS in Wildlife Science BS in Range Science	6
Jennifer Cramer	Social Interest, Economics, and Environmental Justice	BA Biology PhD Plant Biology	6
Michael Frazier	R/H/L/M/E Staff Officer	BA Liberal Arts BS Forestry	44
Larry Gore	Project Manager, Geologist	BS Geology MS Geology	26
Cliff Gibbons	Safety and Occupational Health Specialist	BS Biology	17
Joshua Hall	Air Quality Specialist	MS Environmental Science MA Environmental Policy and Natural Resource Management	11
Lee Harrelson	Forest Engineer	BS Civil Engineering	31
Sandy Hurlocker	NEPA Specialist	BS Science Ed. MS Journalism	25
Heidi Klingel	Soils and Hydrology Specialist	BS Earth Science MS Geosciences	11
Julie Luetzelschwab	Forest Resource Information Coordinator	BA, MA Environmental Geography	19
Steve Miranda	Fire Management Specialist	BS Rangeland Management	22
Cecil Rich	Fish Biologist	BS Biology MS Fish Ecology PhD Fisheries and Aquatic Science	20

EMPSi – Environmental Management and Planning Solutions, Inc. (*Contractor*)

Team Member	Resource/Resource Program	Education	Years of Experience
David Batts	Principal-in-Charge	MS Natural Resource Planning	23
Kevin Rice	Project Management, Biological Resources	BS Environmental Science	6
Kevin Doyle	Cultural Resources	BA Sociology	30
Nick Parker	Land Use, Recreation, Special Designations, and Transportation and Access	MA Archaeology BA Earth Science and Cultural Geography	16
Katie Patterson	Geologic Resources	JD Environmental Law	7
Alex Finch	Geologic Resources	JD Natural Resources Law and Policy	4
Melissa Estep	Soil and Water Resources	BS Industrial & Systems Engineering	4
Laura Patten	Air Quality, Climate Change	MS Environmental Law and Policy	5
Amy Cordle	Air Quality, Climate Change	BS Civil Engineering	18
Daniel Robinson	Biological Resources	BS Wildlife Ecology and Conservation	10
Kate Krebs	Visual Resources	BA Environmental Studies, Spanish	10
Drew Vankat	Health and Safety, Noise,	MS Environmental Policy and Planning	11
Zoe Ghali	Social Interests, Economics, and Environmental Justice	MS Integrative Physiology (Environmental Physiology)	8
Sarah Crump	Social Interests, Economics, and Environmental Justice	BA Environmental Studies, Political Science	3
Holly Prohaska	Livestock Grazing/QA	MS Environmental Management	15
Marcia Rickey	GIS	MS Biology, Conservation Biology Sequence	15
Jacob Accola	GIS	BA Environmental Design	2

Cooperating Agency Team Members and Other Contributors

Team Member	Resource/Resource Program	Education	Years of Experience
Linda Dansby	Energy and Minerals Coordinator, Intermountain Region, NPS	BS Biology	38
Fraser Goff	Geothermal Consultant to the NPS	BS Chemistry PhD Earth Sciences	41

Cooperating Agency Team Members and Other Contributors

Team Member	Resource/Resource Program	Education	Years of Experience
Ross Klein	Natural Resource Specialist – Minerals, BLM	BS Renewable Natural Resources MS Rangeland Ecology and Management	8
Sheila Mallory	Deputy State Director, BLM	BS Geology MS Economic Geology	15
Mark Meyer	Renewable Energy Visual Resource Specialist, Air Resources Division, NPS	BS Design Landscape Architecture MS Natural Science	34
Robert Parmenter	Biological Scientist/Division Chief, Science and Resource Stewardship, Valles Caldera, NPS	BA Biology MS Zoology PhD Biology/Ecology	42
Mark Peyton	Wildlife Biologist/Technician, Valles Caldera National Preserve, NPS	MS Forestry MS Wildlife Science	12
Ana Steffen	Archaeologist, Valles Caldera National Preserve, NPS	BA Biology MS Zoology PhD Biology/Ecology	25
Randy Stanley	Natural Sounds & Night Skies Coordinator, Intermountain Region, NPS	BSE Acoustical Engineering M.Eng Acoustics	18
Martina Suazo	Plant Ecologist/Technician, Valles Caldera National Preserve, NPS	BS Biology	5
John Swigart	Cartographer, Valles Caldera National Preserve, NPS	BA Anthropology MA Anthropology	20

4.1.2 Federal, State, and Local Agencies

- Bureau of Land Management
- National Park Service

4.1.3 Tribes

- Canoncito Navajo Chapter House
- Counselor Navajo Chapter House
- Crownpoint Navajo Chapter House
- Jicarilla Apache Nation
- Kewa Pueblo (Pueblo of Santo Domingo)
- Mescalero Apache Tribe
- Ohkay Owingeh
- Ojo Encino Navajo Chapter House
- Pueblo of Acoma

- Pueblo of Cochiti
- Pueblo of Isleta
- Pueblo of Jemez
- Pueblo of Laguna
- Pueblo of Nambé
- Pueblo of Picuris
- Pueblo of Pojoaque
- Pueblo of San Felipe
- Pueblo of San Ildefonso
- Pueblo of Santa Ana
- Pueblo of Santa Clara
- Pueblo of Taos
- Pueblo of Tesuque
- Pueblo of Zia
- Pueblo of Zuni
- Pueblo Pintado Navajo Chapter House
- Ramah Navajo Chapter House
- Southern Ute Tribe
- The Hopi Tribe
- The Navajo Nation
- Torreon Navajo Chapter House
- Ute Mountain Ute Tribe
- Whitehorse Lake Navajo Chapter House

4.1.4 Others

- Los Alamos National Laboratory

4.2 List of Agencies, Organizations and Persons Who Were Sent Copies of the DEIS

4.2.1 Federal

- Advisory Council on Historic Preservation
- USDA, Animal and Plant Health Inspection Service
- USDA, Natural Resources Conservation Service
- USDA, National Agriculture Library
- National Oceanic and Atmospheric Administration
- US Army Corps of Engineers
- US Environmental Protection Agency
- Department of Energy
- Department of Interior, Office of Environmental Policy and Compliance

- Federal Aviation Administration
- US Department of Transportation, Federal Highway Administration

In addition, all individual, organizations, and agencies on the project mailing list received notification of the availability of the DEIS.

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Chapter 5. Glossary

Allotment: An area of land where one or more operators graze their livestock. It generally consists of public lands but may include parcels of private or state-owned lands. The number of livestock and period of use are stipulated for each allotment.

Animal unit month (AUM): The amount of forage necessary for the sustenance of one cow or its equivalent for a period of one month (approximately 800 pounds of air-dried material per AUM). A full AUM's fee is charged for each month of grazing by adult animals if the grazing animal 1) is weaned, 2) is six months or older when entering public land, or 3) will become 12 months old during the period of use. For fee purposes, an AUM is the amount of forage used by five weaned or adult sheep or goats or one cow, bull, steer, heifer, horse, or mule. The term AUM is commonly used in three ways: 1) stocking rate, as in X acres per AUM, 2) forage allocation, as in X AUMs in allotment A, and 3) utilization, as in X AUMs consumed from Unit B.

Assessment: The act of evaluating and interpreting data and information for a defined purpose.

Best management practices (BMPs): A suite of techniques that guide, or may be applied to, management actions to aid in achieving desired outcomes.

Buffer: An area of specified width where certain activities may not occur. Buffers are usually defined around special sensitive resources, such as archaeological sites, or along each side of a stream, or near other features to be protected from human disturbance.

Controlled surface use (CSU): The CSU stipulation is intended for application where standard lease terms and permit-level decisions are deemed insufficient to achieve the level of resource protection necessary to protect the public interest, but where an NSO is deemed overly restrictive. A CSU stipulation requires that a proposed facility or activity be relocated by more than 200 meters from the proposed location if necessary to achieve the desired level of protection. A CSU is not required if relocating a proposed facility or activity by up to 200 meters would be sufficient to protect the specified resources.

Condition of approval: A site-specific and enforceable requirement included in an approved application for permit to drill or sundry notice that may limit or amend the specific actions proposed by the operator. Conditions of approval minimize, mitigate, or prevent impacts on resource values or other uses of public lands.

Direct use: Use of geothermal resources for commercial, residential, agricultural, or public facilities or for energy needs other than the commercial production of electricity.

Endangered species: As defined in the federal Endangered Species Act, any species that is in danger of extinction throughout all or a significant portion of its range. For terrestrial species, the US Fish and Wildlife Service determines endangered status.

Environmental impact statement (EIS): A written analysis of the impacts on the natural, social, and economic environment of a proposed project or resource management plan.

Erosion: The wearing away of the land surface by rain or irrigation water, wind, ice, or other natural or human agents that abrade, detach, and remove geologic parent material or soil from one point on the earth's surface and deposit it elsewhere.

Exception: A one-time exemption for a particular site in a leasehold. Exceptions are determined on a case-by-case basis, and the stipulation continues to apply to all other sites in the leasehold. An exception is a limited type of waiver.

Federal land: Land owned by the United States without reference to how the land was acquired or which federal agency administers it, including mineral and coal estates underlying private surface.

Geographic information system (GIS): A computer system capable of storing, analyzing, and displaying data and describing places on the earth's surface.

Geothermal energy: Natural heat from within the earth, captured for production of electric power, space heating, or industrial steam.

Geothermal plant: A plant powered by a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The energy is extracted by drilling or pumping.

Hot dry rock: A type of geothermal technology that refers to the formation of a fully engineered geothermal reservoir in hot crystalline rock by the application of hydraulic fracturing and subsequent circulation of water through that engineered reservoir to mine the thermal energy from the hot rock.

Indirect use: Commercial electrical generation from geothermal resources.

Invertebrates: Animals without back bones.

Known geothermal resource area (KGRA): A region identified by the US Geological Survey as containing geothermal resources. New leasing regulations no longer use KGRAs as a basis for the leasing process.

Lease stipulation: A condition of lease issuance that provides a level of protection for other resource values or land uses by restricting lease operations during certain times or locations or to avoid unacceptable impacts, to an extent greater than standard lease terms or regulations. A stipulation is an enforceable term of the lease contract, supersedes any inconsistent provisions of the standard lease form, and is attached to and made a part of the lease. Lease stipulations further implement the Forest Service's regulatory authority to protect resources or resource values. Lease stipulations are developed through the land use planning process.

Locatable mineral: A mineral subject to location under the 1872 Mining Laws. Examples of such minerals are gold, silver, copper, and lead, as compared to oil and natural gas, which are leasable minerals.

Modification: A change to the provisions of a lease stipulation, either temporarily or for the term of the lease. Depending on the specific modification, the stipulation may or may not apply to all sites within the leasehold to which the restrictive criteria are applied.

National Environmental Policy Act (NEPA) of 1969: A law enacted on January 1, 1970, that established a national policy to maintain conditions under which humans and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of Americans. It established the Council on Environmental Quality for coordinating environmental matters at the federal level and to serve as the advisor to the president on such matters. The law made all federal actions and proposals that could have significant impact on the environment subject to review by federal, state, and local environmental authorities.

Native (indigenous) species: A species of plant or animal that naturally occurs in an area and that was not introduced by humans.

National Forest System lands: Forests and grasslands that the Forest Service manages. Includes both lands reserved from the federal estate and acquired lands.

No surface occupancy (NSO): A fluid minerals leasing constraint that prohibits occupancy or disturbance on all or part of the lease surface to protect special values or uses. Lessees may exploit the fluid mineral resources under the leases restricted by this constraint through the use of directional drilling from sites outside the NSO area.

Open: Generally denotes that an area is available for a particular use or uses. Refers to specific program definitions found in law, regulations, or policy guidance for application to individual programs. For example, 43 CFR, Subpart 8340.0-5, defines the specific meaning of open as it relates to off-highway vehicle use.

Permitted use: The forage allocated by, or under the guidance of, an applicable land use plan for livestock grazing in an allotment under a permit or lease, expressed in AUMs (43 CFR, Subpart 4100.0-5).

Project area: Potential geothermal leasing areas on National Forest Service lands that were identified for the analysis to determine consent to leasing.

Renewable energy: Resources that constantly renew themselves or that are regarded as practically inexhaustible. Examples are solar, wind, geothermal, hydro, and wood. Although particular geothermal formations can be depleted, the natural heat in the earth is a virtually inexhaustible reserve of potential energy. Renewable resources also include some experimental or less developed sources, such as tidal power, sea currents, and ocean thermal gradients.

Right-of-way: An easement or permit that authorizes public land to be used for a specified purpose that generally requires a long narrow strip of land. Examples are roads, power lines, and pipelines.

Seismic exploration: This remains the most common way to locate subsurface resources. The process involves sending sound waves into the earth at one point and recording them at other points after they have passed through different geological strata. There are two common methods used today. The first involves the detonation of small explosive charges; the other consists of a truck that drops a huge weight at various intervals. The data collected is used to show probable subsurface resource deposits.

Site visit: The entry of one person on a site or area to participate in recreation for an unspecified period.

Special status species: Includes proposed species, listed species, and candidate species under the ESA and Forest Service sensitive species, as defined in Forest Service Manual 2670.5 as “those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by 1) significant current or predicted downward trends in population numbers or density, or 2) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution"

Standard lease terms and conditions: Areas may be open to leasing with no specific management decisions; however, these areas are subject to lease terms and conditions, as defined on the lease form (Form 3100-11, Offer to Lease and Lease for Oil and Gas; and Form 3200-24, Offer to Lease and Lease for Geothermal Resources).

State implementation plan: A strategic document, prepared by a state or other authorized air quality regulatory agency and approved by the US Environmental Protection Agency, which thoroughly describes how requirements of the Clean Air Act will be implemented, including standards to be achieved, control measures to be applied, and enforcement actions in case of violation.

Stipulation: A condition of lease issuance that provides protection for other resource values or land uses by establishing authority for substantial delay or site changes or the denial of operations within the terms of the lease contract.

Stipulation standards: The physical and temporal conditions, resources, or resource values that must be present and met for application of a specific stipulation to a specific lease.

Tectonic: A field of study in geology concerned generally with the structure of the crust of the earth and particularly with the forces and movements that have operated in a region to create geomorphic features.

Timing limitation (TL): This stipulation limits activity during a specified period of the year. A TL stipulation is intended for application where standard lease terms are deemed insufficient to achieve the level of resource protection necessary to protect the public interest, but where an NSO is deemed overly restrictive. The scope of the TL stipulation goes beyond ground-disturbing activities to encompass any source of protracted or high-intensity disturbance that could interfere with normal wildlife behavior and adversely affect habitat use. The limitation is applied annually for a specified period lasting more than 60 days. Under the proposed plan, TLs may also be applied to land uses and activities other than oil and gas development.

Transmission: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points where it is transformed for delivery to consumers or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Threatened species: 1) Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range, and 2) as further defined by the Endangered Species Act of 1973.

Tribal interests: Native American or Native Alaskan economic rights, such as Indian trust assets, resource uses and access guaranteed by treaty rights, and subsistence uses.

Traditional cultural resources or properties: Areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas.

Utility: A regulated entity that exhibits the characteristics of a natural monopoly. For the purposes of electric industry restructuring, it refers to a regulated, vertically integrated electric company. Transmission utility refers to the regulated owner or operator of the transmission system only. Distribution utility refers to the regulated owner or operator of the distribution system that serves retail customers.

Vertebrate: Animals with back bones, including fish, amphibians, reptiles, birds, and mammals.

Waiver: A permanent exemption from a lease stipulation that no longer applies anywhere within the leasehold.

Watershed:

- **First Level:** The first level of classification divides the nation into 21 major geographic areas, or regions. These geographic areas contain either the drainage area of a major river, or the combined drainage areas of a series of rivers.
- **Second Level:** The second level of classification divides the 21 regions into 221 subregions. A subregion includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin(s), or a group of streams forming a coastal drainage area.
- **Third Level:** The third level of classification subdivides may of the subregions into accounting units. These 378 hydrologic accounting units are nested within, or can be equivalent to the subregions.
- **Fourth Level:** The four level of classification is the cataloging unit. A cataloging unit is a geographic area representing part of or all of a surface drainage basin, a combination of drainage basins, or distinct hydrologic feature. These units subdivide the subregions and accounting units into smaller areas. There are 2,264 cataloging units in the Nation.

Watt: The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.

Watt-hour: An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Wilderness area: An area of public land designated by an act of Congress to be protected in its natural condition according to the requirements of the Wilderness Act of 1964.

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Appendix A

Management Areas and Prescriptions from Forest Plan

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Appendix A. Management Areas and Prescriptions from Forest Plan

Management Area	Acres in the Project Area	Management Emphasis	Minerals Standards and Guidelines	Lands and Realty Standards and Guidelines[1]
A	52,500	Emphasis is on timber production and enhancement of wildlife habitat diversity, consistent with other resource integration. Grazing capacity is generally transitory in nature, but there are allotments in intermingled grasslands. Roaded dispersed recreation experiences are emphasized. Firewood is provided as a by-product of timber harvesting.	G04 – mineral leasing category: Standard	J01 – Unclassified for utility corridors
B	14,100	The emphasis in this area is on wildlife habitat improvement and key species habitat protection. Grazing and timber harvesting occur where they are compatible with the primary emphasis of this area. Recreation is mostly of a dispersed roaded nature. Timber harvesting slash will be provided for wildlife and firewood.	G04 – mineral leasing category: Standard	J01 – Unclassified for utility corridors
C	1,200	Emphasis is on enhancing visual quality and developed recreation opportunities, while protecting essential wildlife habitat and riparian zones. Grazing and timber harvesting occur where consistent with the primary emphasis of this area.	G04 – mineral leasing category: Limited Use	J01 – Classification for power lines in excess of 69 kV: Avoidance
D	<100	Emphasis is on enhancing visual quality and developed recreation opportunity. Grazing and timber harvesting occur where they are consistent with the primary emphasis of this area.	G04 – mineral leasing category: Limited Surface Use	J01 – Classification for power lines in excess of 69 kV: Avoidance
E	17,700	Emphasis is on providing dispersed recreation opportunities, maintaining visual quality, and harvesting timber and firewood. Grazing activities vary in intensity over this area. Emphasis is on maintaining or enhancing wildlife habitat diversity.	G04 – mineral leasing category: Standard	J01 – Unclassified for utility corridors
F	3,300	Management area F is specific to the Jemez Wild and Scenic River. Emphasis is on prohibiting road construction and motorized use, managing for high scenic integrity objective, and managing for semi-primitive nonmotorized recreation opportunity spectrum setting.	Closed to new mineral leasing	Prohibit new road construction

Appendix A. Management Areas and Prescriptions from Forest Plan

Management Area	Acres in the Project Area	Management Emphasis	Minerals Standards and Guidelines	Lands and Realty Standards and Guidelines[1]
G	8,600	Emphasis in this area is on protecting key wildlife habitats, improving habitats, and producing forage and firewood. Recreational opportunities are dispersed and consist of firewood and pinyon nut gathering, hunting, and recreational driving.	G04 – mineral leasing category: Standard	J01 – Unclassified for utility corridors
L	4,300	Emphasis is on providing semi-primitive nonmotorized recreation opportunities. Wildlife, range, and fuels may be managed where it is consistent with this emphasis. Timber harvesting and road building are not consistent with this emphasis, and neither is scheduled in this planning period. These areas will receive priority in dispersed recreation management, trail and trailhead development, and trail maintenance.	G04 – Mineral leasing category: Limited Surface Use	J01 – Classification for power lines in excess of 69 kV: Avoidance
M	600	These areas will be managed to provide opportunities for non-disruptive research and education. This management includes allowing natural processes to occur and protecting natural features. Use restrictions will be imposed as necessary to keep areas in their natural or unmodified condition. No timber or firewood will be harvested, nor will this area be assigned any grazing capacity.	G04 – Mineral leasing category: Limited Surface Use – No Surface Occupancy	J01 – Utility corridors are excluded
N	6,700	The emphasis here will be on management that protects and enhances essential wildlife habitat. This land area will not be included in the suitable timber base. However, certain timber management activities—as well as grazing, firewood collection, and fire management—may occur, when they are consistent with the emphasis on protecting this area.	G04 – Mineral leasing category: Limited Surface Use	J01 – Classification for power lines in excess of 69 kV: Avoidance

Appendix A. Management Areas and Prescriptions from Forest Plan

Management Area	Acres in the Project Area	Management Emphasis	Minerals Standards and Guidelines	Lands and Realty Standards and Guidelines[1]
P	9,800	Cultural resource location, inventory, nomination, and protection are emphasized here. Emphasis is also on timber production and enhancement of wildlife habitat diversity, consistent with other resource integration. Grazing capacity is generally transitory in nature, but there are allotments in intermingled grasslands. Roaded, dispersed recreation experiences are emphasized. Firewood is provided as a by-product of timber harvesting.	G04 – Mineral leasing category: Standard	J01 – Unclassified for utility corridors
Q	3,200	Cultural resource site location, inventory, nomination, and protection in these areas are emphasized. The emphasis is also on providing dispersed recreation opportunities, while maintaining visual quality, timber harvesting, and firewood production. Grazing activities vary in intensity over this area. The emphasis is on maintaining or enhancing wildlife habitat diversity. Cultural resource site location, inventory, nomination, and protection in these areas are emphasized.		

Source: Forest Service 1987

[1] Excludes Forest-Wide Standards and Guidelines

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Appendix B

Stipulations and Closures by Alternative

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Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	2	3	4
Fish and Wildlife						
Designated or proposed critical habitat	Surface occupancy and use is prohibited on designated or proposed critical habitat for listed species under the Endangered Species Act of 1973 (as amended), as following: • New Mexico meadow jumping mouse • Mexican spotted owl • Jemez mountain salamander	**Purpose:** To avoid surface disturbance activities that would result in loss of critical habitat within these distinct localized areas **Changes:** An exception, modification, or waiver may be granted if an operator could demonstrate in a site-specific surface use plan of operations that adverse impacts on habitat could be completely avoided and clearance is obtained from the agency biologist and the US Fish and Wildlife Service.		•		•
Cultural Resources						
Areas with important cultural resources	Surface occupancy and is prohibited at the following: • Traditional cultural properties and Native American sacred sites, as identified through consultation • Properties listed on or eligible for listing on the National Register of Historic Places, including National Landmarks and National Register Districts and Sites; also, additional lands outside the designated boundaries, to the extent necessary to protect values where the setting and integrity is critical to their designation or eligibility • Areas that qualify for cultural resource protection based on Forest Plan criteria (Planning Areas P, Q, and R)	**Purpose:** To avoid surface disturbance activities that would result in irreversible loss of cultural resources within these areas where cultural resource avoidance or data recovery are not viable options **Changes:** An exception, modification, or waiver may be granted if an operator's site-specific surface use plan of operations were to demonstrate that adverse impacts on the cultural resources could be completely avoided, and clearance is recommended, in accordance with the requirements of Section 106 of the National Historical Preservation Act, and approved by the Forest Supervisor.		•		•
Water Resources and Water Quality						
Water bodies, rivers and streams (perennial and intermittent), riparian areas, wetlands, playas, 100-year floodplains, and a	Surface occupancy and use is prohibited within a 500-foot-wide protection zone, measured horizontally from the outer edge of each feature for the following: • Water bodies, rivers and streams (perennial and intermittent),	**Purpose:** To avoid adverse impacts on riparian and wetland resources, to prevent development in floodplains, and to remain consistent with law (Clean Water Act), regulation, and policy (National BMPs) **Changes:** An exception or modification may be granted if surveys show that the area of a proposed activity is not a water		•		

Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	2	3	4
500-foot-wide protection zone around them	wetlands, and playas (mapped in the USGS National Hydrography Dataset [NHD]) • Riparian areas are protected by a 500-foot-wide buffer. They are approximately mapped within the terrestrial ecosystem survey and vegetation data sets (includes Terrestrial Ecosystem Units 3-8, 10, 11, 13, 31, 33, 34, 38, 234, 320, and 334), but they may also need site-specific field delineation. • The 100-year floodplain (surrounding some features) needs to be delineated through field geomorphology surveys, stream gage data, and hydrologic modelling.	feature and that impacts on a water feature are not likely to occur. Roads and power lines may cross these areas if the operator can show that crossing the water feature and protection zone will have less environmental impact than other routes and that adverse effects can be minimized.				
Water bodies, perennial rivers and streams, riparian areas, wetlands, playas, 100-year floodplains, and a 500-foot-wide protection zone around them.	Surface occupancy and use is prohibited within a 500-foot wide protection zone measured horizontally from the outer edge of each feature for the following: • Water bodies, perennial rivers and streams, wetlands, and playas (mapped in the USGS NHD) • Riparian areas are protected by a 500 foot-wide buffer. They are approximately mapped within the terrestrial ecosystem survey and vegetation data sets (includes Terrestrial Ecosystem Units 3-8, 10, 11, 13, 31, 33, 34, 38, 234, 320, and 334), but they may also need site specific field delineation. • The 100-year floodplain (surrounding some features) needs to be delineated through field geomorphology surveys,	**Purpose:** To avoid adverse impacts on riparian and wetland resources, to prevent development in floodplains, and to remain consistent with law (Clean Water Act), regulation, and policy (National BMPs). **Changes:** An exception or modification may be granted if surveys show that the area of a proposed activity is not a water feature and that impacts on a water feature are not likely to occur. Roads and power lines may cross these areas if the operator can show that crossing the water feature and protection zone will have less environmental impact than other routes and that adverse effects can be minimized.				•

Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	stream gage data and hydrologic modelling.					
Acequias and a 50-foot protection zone	Surface occupancy and use is prohibited within a 50-foot protection zone, as measured horizontally from the outer edge of the ditch for acequias with the Office of the State Engineer (OSE) recognized water rights.	**Purpose:** To avoid adverse impacts on riparian and wetland resources and impairment of existing water rights **Changes:** An exception or modification may be granted if surveys show that impacts on the acequia are not likely to occur and the New Mexico Acequia Commission agrees. Roads and power lines may cross these areas if the operator can show that crossing the acequia and protection zone would have less environmental impact than other routes and that adverse effects could be minimized.		•		•
New Mexico Office of the State Engineer Recognized Water Sources and a 1-mile protection zone around them	Surface occupancy and use is prohibited within a 1-mile protection zone for New Mexico OSE-recognized water sources. In the project boundary, these are as follows: • Known drinking water sources • Known wells • Known springs	**Purpose:** To protect the water quality and quantity of water sources. Protecting water sources will help the Forest Service comply with its own management direction, such as the Santa Fe National Forest Plan (1987) and FSM 2500; laws, such as the Clean Water Act (1972) and the Safe Drinking Water Act (1974); and regulations, such as New Mexico water quality standards, water rights. and permits. **Changes:** An exception or modification may be granted if the operator's surface and subsurface hydrology studies and mitigation plans were to show there is no reasonable risk to the quality or quantity at a water source. Roads and power lines may cross a water source protection zone if the operator can demonstrate that it would have less environmental impact than other routes and that adverse effects could be minimized.		•		
New Mexico OSE-recognized drinking water sources and a 1-mile protection zone around them	Surface occupancy and use is prohibited within a 1-mile protection zone for OSE-recognized drinking water sources, such as that within the project boundary.	**Purpose:** To protect the water quality and quantity of water sources. Protecting water sources will help the Forest Service comply with its own management direction, such as the Santa Fe National Forest Plan (1987) and FSM 2500; law, such as the Clean Water Act (1972) and the Safe Drinking Water Act (1974); and regulation, such as the New Mexico water quality standards, water rights, and permits. **Changes:** An exception or modification may be granted if the				•

Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
		operator's surface and subsurface hydrology studies and mitigation plans were to show that there is no reasonable risk to the quality or quantity at a water source. Roads and power lines may cross a water source protection zone if the operator can demonstrate that it would have less environmental impact than other routes and that adverse effects could be minimized.				
Geologic Resources						
Natural geothermal features and a 1-mile protection zone around them	Surface occupancy and use is prohibited on thermal features. These are defined broadly as places on the earth's surface with natural discharges of elevated temperature groundwater. Within the project area boundary there are two known hot springs outside of the Jemez NRA: San Antonio Hot Springs and Sulphur Springs, which is on private land, but the protection zone extends onto Forest Service lands. A 1-mile (radius) protection zone would surround any known or currently unknown thermal feature, within which the area would be closed to all surface occupancy.	**Purpose:** To protect the water quality, water quantity, unique ecosystems, and cultural values these features hold. **Changes:** An exception or modification may be granted if the operator's surface and subsurface hydrology studies and mitigation plans were to show that there is no reasonable risk to the quality or quantity of water creating the feature. Roads and power lines may cross these areas if the operator can demonstrate there are no practicable alternatives and that adverse effects could be minimized. Detailed plans for mitigations to adverse effects would be required with the application for exception or modification.				•
Soils						
Slopes in excess of 40 percent	Surface occupancy and use is prohibited on slopes equal to or in excess of a 40 percent grade. These areas are extremely susceptible to erosion and mass wasting.	**Purpose:** To preclude surface-disturbing activities on steep slopes, because these areas tend to have high erosion and a mass wasting hazard. Additionally, water quality is more likely to be impaired where steep slopes have been developed. Without this protection there would be a high risk of impairing long-term soil productivity and watershed conditions. Additionally, these precautions must be taken to remain consistent with Forest Service policy. **Changes:** An exception or modification may be granted if on-site inspection were to show that unstable or steep slopes do not exist on the specific site, or if the operator could demonstrate in a plan of operations that adverse effects could		•		•

Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	2	3	4
		be minimized and activities safely conducted without a loss of long-term site productivity. Power lines and roads may cross slopes equal to or exceeding a 40 percent gradient. Where this occurs, any vegetation or ground disturbance must have a minimal impact on the hydrologic network. This can be achieved through proper implementation of best management practices (BMPs) and by designing for sufficient and appropriate water control.				
Soils with severe erosion potential	Surface occupancy and use is prohibited on all soils with severe erosion potential, as defined by the Forest Service Terrestrial Ecological Unit geographical information system (GIS) layers.	**Purpose:** To preclude surface-disturbing activities on severely erosive soils, because these areas are likely to erode. Without this protection there would be a high risk of impairing long-term soil productivity and watershed conditions. Additionally, these precautions must be taken to remain consistent with Forest Service policy. **Changes:** An exception or modification may be granted if onsite inspection were to show that soils with severe erosion potential do not exist on the specific site, or if the operator could demonstrate in a plan of operations that adverse effects could be minimized and activities safely conducted without the loss of long-term site productivity. Power lines and roads may cross areas with severely erosive soils. Where this occurs, any vegetation or ground disturbance must incorporate BMPs to minimize erosion potential.		•		
Land Use, Recreation, and Special Designations						
Developed recreation facilities	Surface occupancy and use is prohibited on the following developed recreation facilities: • San Antonio Creek Recreation Area • Seven Springs Recreation Area • Paliza Recreation Area	**Purpose:** To avoid incompatible development that would impact developed recreation facilities and sites. **Changes:** No exceptions, waivers, or modifications would be considered.		•		

Table B-1. No Surface Occupancy Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose and Changes (Exception, Modification, or Waiver)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Developed recreation facilities and Forest Service administrative sites	Surface occupancy and use is prohibited on the following developed recreation facilities and Forest Service administrative sites: • San Antonio Creek Recreational Area • Seven Springs Recreation Area • Paliza Recreation Area • Seven Springs Administrative Site • Encino Administrative Site • Encino Point Administrative Site • Cerro Pelado Lookout Administrative Site	**Purpose:** To avoid incompatible development that would impact developed recreation facilities and administrative sites. **Changes:** No exceptions, waivers, or modifications would be considered.				•
Inventoried roadless areas	Surface occupancy and use is prohibited on inventoried roadless areas.	**Purpose:** To keep surface disturbance activities outside the inventoried roadless area. This stipulation is needed to protect and maintain the roadless, semiprimitive, and nonmotorized character of these special areas. Examples are such elements as natural integrity, natural appearance, opportunity for quiet and solitude, manageability of boundaries, and special features, such as ecological, geological, scenic, cultural features. **Changes:** No exceptions, waivers, or modifications would be considered.		•		•
Visual Resources						
National Forest System lands with a Scenery Management System integrity level of very high	Surface occupancy and use is prohibited on National Forest System lands with a Scenery Management System integrity level of very high. This is Management Area L in the SFNF Forest Plan.	**Purpose:** To protect important viewsheds. **Changes:** An exception, modification, or waiver may be granted if an operator's site-specific surface use plan of operations were to demonstrate that adverse impacts on the viewshed would not occur.		•		

Table B-2. Controlled Surface Use Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose, Changes (Exception, Modification, or Waiver)	Alternative			
			1	2	3	4
Soils						
Slopes between 30 and 40 percent	Design and locate all surface-disturbing activities to minimize soil erosion. Erosion factors include fugitive dust, wind, and stormwater runoff. BMPs would be applied to all sites containing these soils, and additional measures may be required.	**Purpose:** To preclude surface-disturbing activities on slopes that tend to have high erosion and a mass wasting hazard. Additionally, water quality is more likely to be impaired where slopes have been developed. Without this protection there would be a risk of impairing long-term soil productivity and watershed conditions. Additionally, these precautions must be taken to remain consistent with Forest Service policy. **Changes:** An exception or modification may be granted if on-site inspection were to show that unstable or steep slopes do not exist on the specific site, or if the operator could demonstrate in a plan of operations that adverse effects could be minimized and activities safely conducted without loss of long-term site productivity. Power lines and roads may cross these slopes. Where this occurs, any vegetation or ground disturbance must have a minimal impact on the hydrologic network. This could be achieved through proper implementation of BMPs and designing for sufficient and appropriate water control.		•		•
Soils with severe erosion potential	Design and locate all surface-disturbing activities to minimize soil erosion. Erosion factors are fugitive dust, wind, and stormwater runoff. BMPs would be applied to all sites containing these soils, and additional measures may be required.	**Purpose:** To limit and modify surface-disturbing activities on severely erosive soils, because these areas are likely to erode. Without this protection there would be a high risk of impairing long-term soil productivity and watershed conditions. Additionally, these precautions must be taken to remain consistent with Forest Service policy. **Changes:** An exception or modification may be granted if on-site inspection were to show that soils with severe erosion potential do not exist on the specific site. Power lines and roads may cross areas with severely erosive soils. Where this occurs, any vegetation or ground disturbance must incorporate BMPs to minimize erosion potential.				•

Table B-2. Controlled Surface Use Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose, Changes (Exception, Modification, or Waiver)	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Water Resources and Water Quality						
Intermittent streams listed in the NHD and ephemeral drainages delineated by site-specific mapping	Design and locate all surface-disturbing activities to minimize or avoid impacts on intermittent and ephemeral drainages. BMPs would be applied to all sites containing these features, and additional measures may be required.	**Purpose:** To limit and modify surface-disturbing activities on severely erosive soils, because these areas are likely to erode. Without this protection there would be a high risk of impairing long-term soil productivity and watershed conditions. Additionally, these precautions must be taken to remain consistent with Forest Service policy. **Changes:** An exception or modification may be granted if on-site inspection were to show that intermittent streams or ephemeral drainages do not exist on the specific site. Power lines and roads may cross intermittent streams or ephemeral drainages. Where this occurs, any vegetation or ground disturbance must incorporate BMPs to minimize erosion potential.				•
New Mexico OSE-recognized wells and springs	Design and locate all surface-disturbing activities to minimize soil erosion. BMPs will be applied to all sites, and additional measures may be required. Proper drilling and casing processes will be required to protect groundwater quality.	**Purpose:** To limit and modify surface-disturbing activities near springs and wells that might impact water quality. Without this protection there would be a high risk of impairing water quality. Additionally, these precautions must be taken to remain consistent with Forest Service policy. To limit activities that would impact groundwater quantity or quality. Without this protection, the owner's water right could be impaired. **Changes:** An exception or modification may be granted if on-site inspection were to show that the spring does not exist on the specified site.				•
Land Use, Recreation, and Special Designations						
Dispersed recreational areas	Locate and design surface disturbance activities to be compatible with dispersed recreational use. Also, reclaim disturbed areas to be substantially unnoticeable to dispersed recreational users within 1 to 3 years of project startup. Generally, this can be met by following BMPs.	**Purpose:** To minimize the potential for adverse impacts on recreational values, both motorized and nonmotorized, and the natural settings associated with the recreation. **Changes:** An exception, modification, or waiver may be granted if the operator could demonstrate that the proposed surface disturbance would have less environmental impact than placing the surface-disturbing activity elsewhere and that adverse effects could be minimized.		•		•

Table B-2. Controlled Surface Use Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose, Changes (Exception, Modification, or Waiver)	Alternative 1	2	3	4
Visual Resources						
Viewsheds with a Scenery Management System integrity level of high	Locate and design surface disturbance activities to be consistent with the scenic integrity of high or to reclaim disturbed areas to meet the visual quality objective within 5 years of project startup. Generally, this can be met by following BMPs for minimizing impacts on visual quality, along with visual quality guidelines in the Forest Plan and Forest Service Scenery Management System Handbook (Agriculture Handbook 701).	**Purpose:** To protect the long-term scenic values in areas of high scenic integrity, consistent with Forest Service directives and the Forest Plan. **Changes:** An exception, modification, or waiver may be granted if the operator were to demonstrate in a site-specific surface use plan of operations that adverse impacts on the viewshed would not occur.		•		
Viewsheds with a Scenery Management System integrity level of very high and high	Locate and design surface disturbance activities to be consistent with the scenic integrity or to reclaim disturbed areas to meet the visual quality objective within 5 years of project startup. Generally, this can be met by following BMPs for minimizing impacts on visual quality, along with visual quality guidelines in the Forest Plan and Forest Service Scenery Management System Handbook (Agriculture Handbook 701).	**Purpose:** To protect the long-term scenic values in areas of high scenic integrity, consistent with Forest Service directives and the Forest Plan. **Changes:** An exception, modification, or waiver may be granted if the operator were to demonstrate in a site-specific surface use plan of operations that adverse impacts on the viewshed would not occur.				•

Table B-3. Timing Limitation Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose, Changes (Exception, Modification, or Waiver)	Alternative			
			1	2	3	4
Threatened and Endangered Species and Special Status Species						
Mexican spotted owl designated protected activity centers (PACs)	Timing limitation would be imposed on drilling operations and construction activities from March 1 to August 31.	**Purpose:** To protect and limit disturbance from drilling and construction within Mexican spotted owl PACs (nesting/fledging areas). This would be to minimize risks to the owl's reproductive and post-fledging success during the critical nesting/breeding period. This is defined in the recovery plan for this federally listed threatened species, as well as in the Forest Plan (Appendix D, p. 2). This stipulation would not apply to daily operations and maintenance. **Changes:** An exception, modification, or waiver to the timing limitation may be granted if an operator's site-specific surface use plan of operations were to demonstrate that adverse impacts on threatened and endangered species could be avoided, effects were documented in a biological assessment, and concurrence from the US Fish and Wildlife Service were obtained.		•		•
Northern goshawk designated Post-fledging areas (PFAs)	Timing limitation would be imposed on drilling operations and construction activities from March 1 to September 30.	**Purpose:** To protect and limit disturbance from drilling and construction within northern goshawk nesting PFAs. This would be to minimize risks to reproductive and post-fledging success of northern goshawks during the critical nesting/breeding period, defined in interagency goshawk guidelines and the Forest Plan (Appendix D, pp. 6, 10). This stipulation would not apply to daily operations and maintenance. **Changes:** An exception, modification, or waiver to the timing limitation may be granted if goshawk surveys were to show that the area is not used for nesting.		•		•
Peregrine falcon eyrie nesting areas	Timing limitation would be imposed on drilling operations and construction activities from March 1 to August 15.	**Purpose:** To protect and limit disturbance from drilling and construction in peregrine falcon habitat. This would be to minimize risks to reproductive and post-fledging success of peregrine falcons during the critical nesting/breeding period, consistent with the Forest Plan (p. 63) and Forest Service directives. This stipulation would not apply to daily operations and maintenance. **Changes:** An exception, modification, or waiver to the timing limitation may be granted if surveys were to show that the area is not used for nesting.		•		•

Table B-3. Timing Limitation Stipulations for Geothermal Leasing

Resource	Stipulation	Purpose, Changes (Exception, Modification, or Waiver)	Alternative			
			1	2	3	4
Elk calving areas	Timing limitation would be imposed on drilling operations and construction activities from June 1 to July 31.	**Purpose:** To protect and limit disturbance from drilling and construction in important elk calving areas. This would be to minimize risks to herd reproduction during a critical period. This stipulation would not apply to daily operations and maintenance. **Changes:** An exception or modification to the timing limitation may be granted if the operator were to demonstrate that the drilling/construction location would not disrupt deer fawning and elk calving.		•		•

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Figure 2-4. Alternative 2 – The Proposed Action Available for Leasing Subject to Timing Limitations

Figure 2-5. Alternative 4 – The Development Alternative Closed to Leasing

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Figure 2-7. Alternative 4 – The Development Alternative Available for Leasing Subject to Controlled Surface Use

Figure 2-8. Alternative 4 – The Development Alternative Available for Leasing Subject to Timing Limitations

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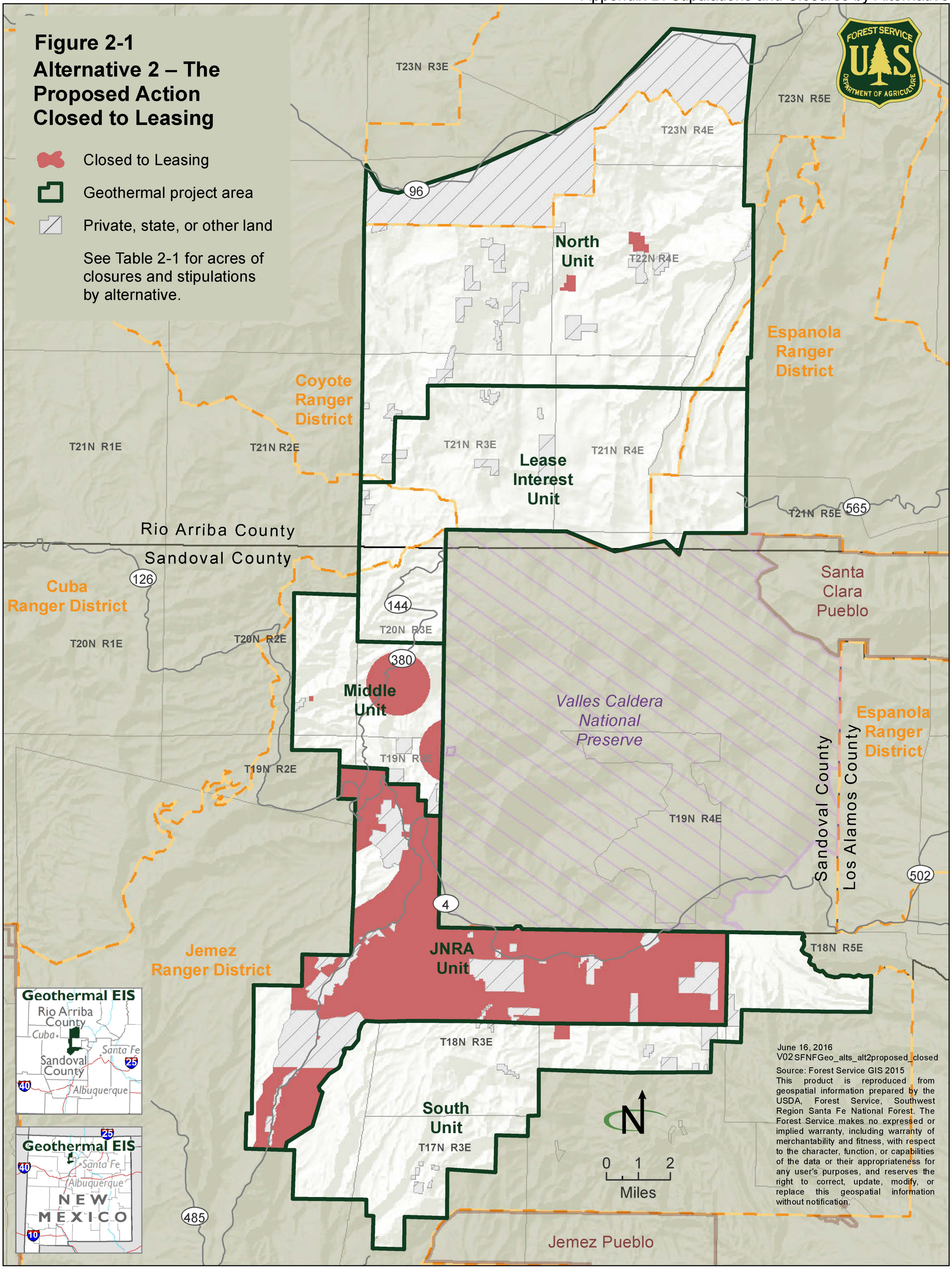

Figure 2-1
Alternative 2 – The Proposed Action Closed to Leasing

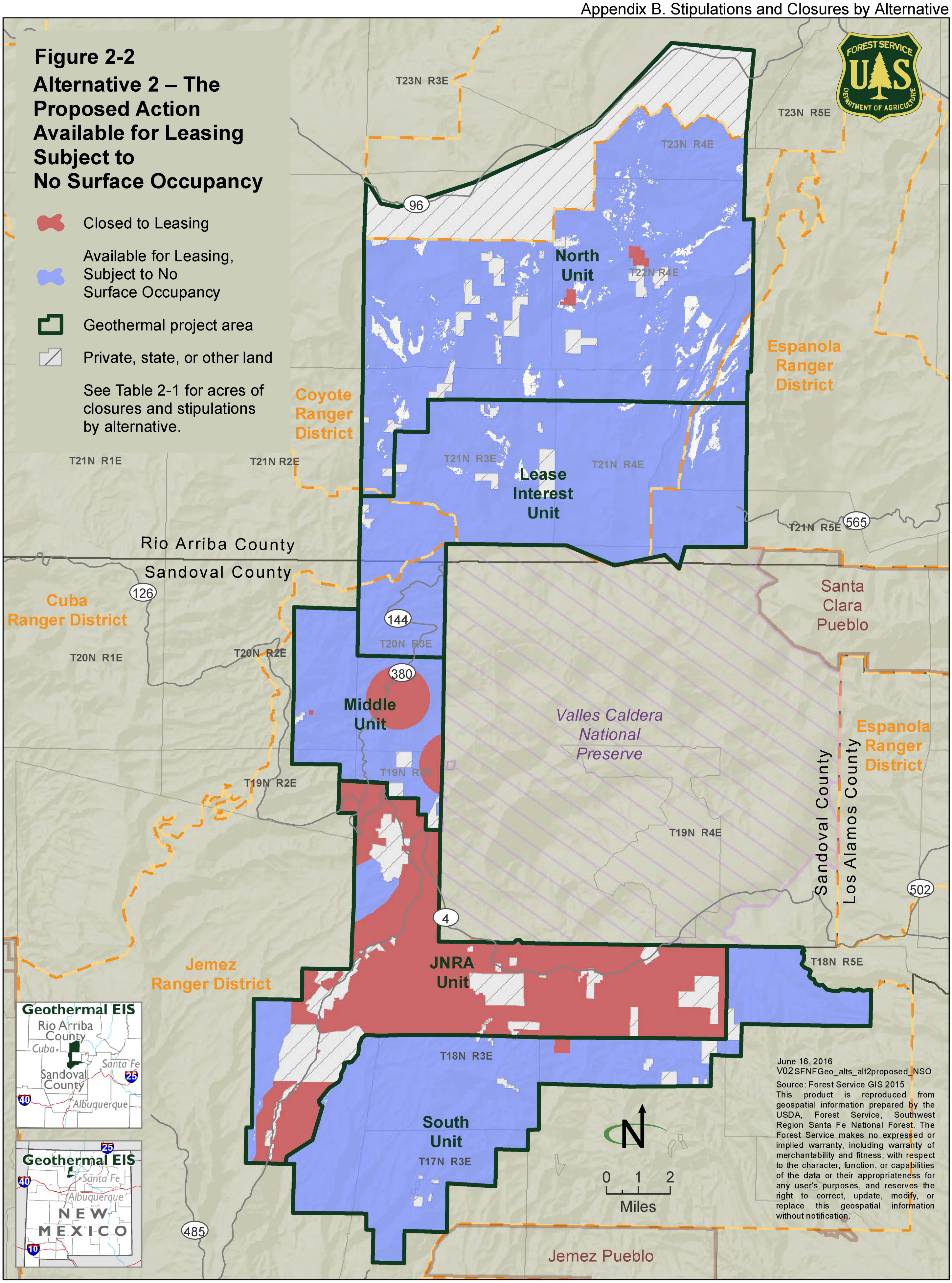
Figure 2-2
Alternative 2 – The Proposed Action Available for Leasing Subject to No Surface Occupancy
Closed to Leasing
Available for Leasing, Subject to No Surface Occupancy
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
T23N R3E
T23N R4E
T23N R5E
96
North Unit
T22N R4E
Espanola Ranger District
Coyote Ranger District
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
Lease Interest Unit
565
Rio Arriba County
Sandoval County
126
Cuba Ranger District
144
Santa Clara Pueblo
T20N R1E
T20N R2E
T20N R3E
380
Middle Unit
Valles Caldera National Preserve
Espanola Ranger District
T19N R2E
T19N R3E
T19N R4E
Sandoval County
Los Alamos County
502
4
Jemez Ranger District
JNRA Unit
T18N R5E
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
25
40
Albuquerque
T18N R3E
South Unit
T17N R3E
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
10
485
N
0 1 2
Miles
Jemez Pueblo
June 16, 2016
V02SFNFGeo_alts_alt2proposed_NSO
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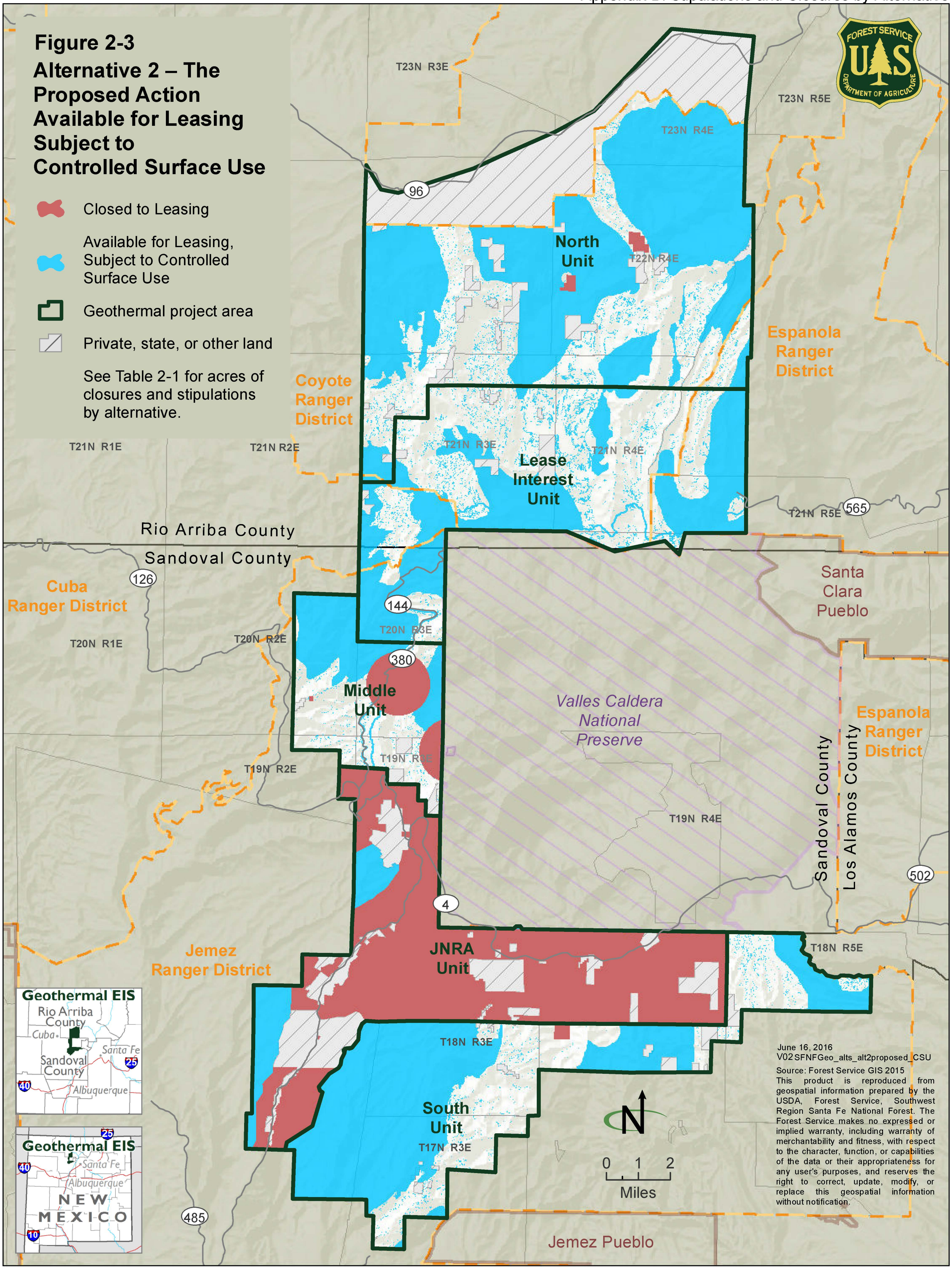
Figure 2-3
Alternative 2 – The Proposed Action Available for Leasing Subject to Controlled Surface Use
Closed to Leasing
Available for Leasing, Subject to Controlled Surface Use
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
T23N R4E
T23N R5E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
96
565
126
144
380
4
502
485
N
0 1 2
Miles
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
NEW MEXICO
June 16, 2016
V02SFNFGeo_alts_alt2proposed_CSU
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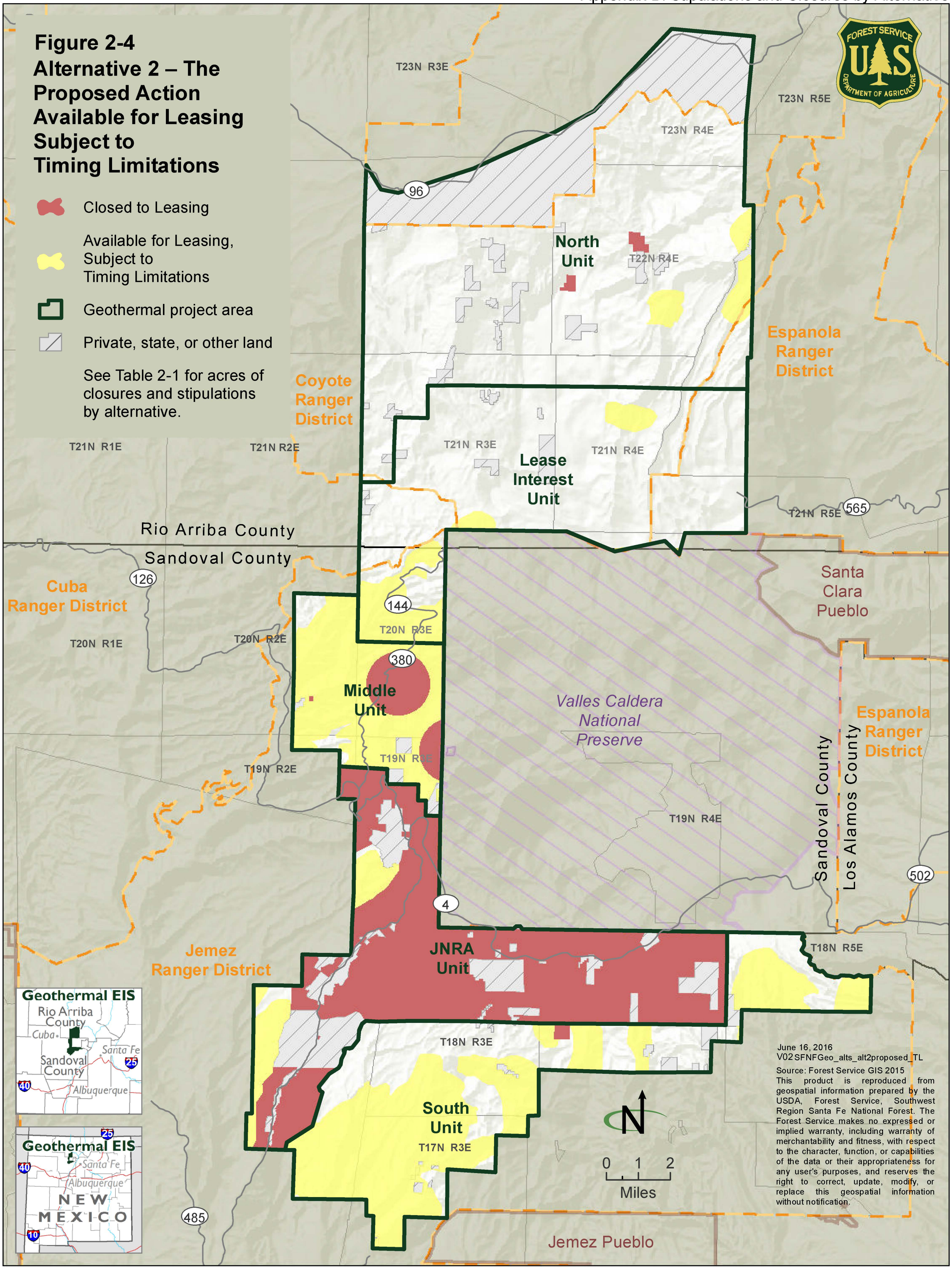
Figure 2-4
Alternative 2 – The Proposed Action Available for Leasing Subject to Timing Limitations
Closed to Leasing
Available for Leasing, Subject to Timing Limitations
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
T23N R4E
T23N R5E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
96
565
126
144
380
4
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485
N
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Miles
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
25
40
Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
10
June 16, 2016
V02 SFNFGeo_alts_alt2proposed_TL
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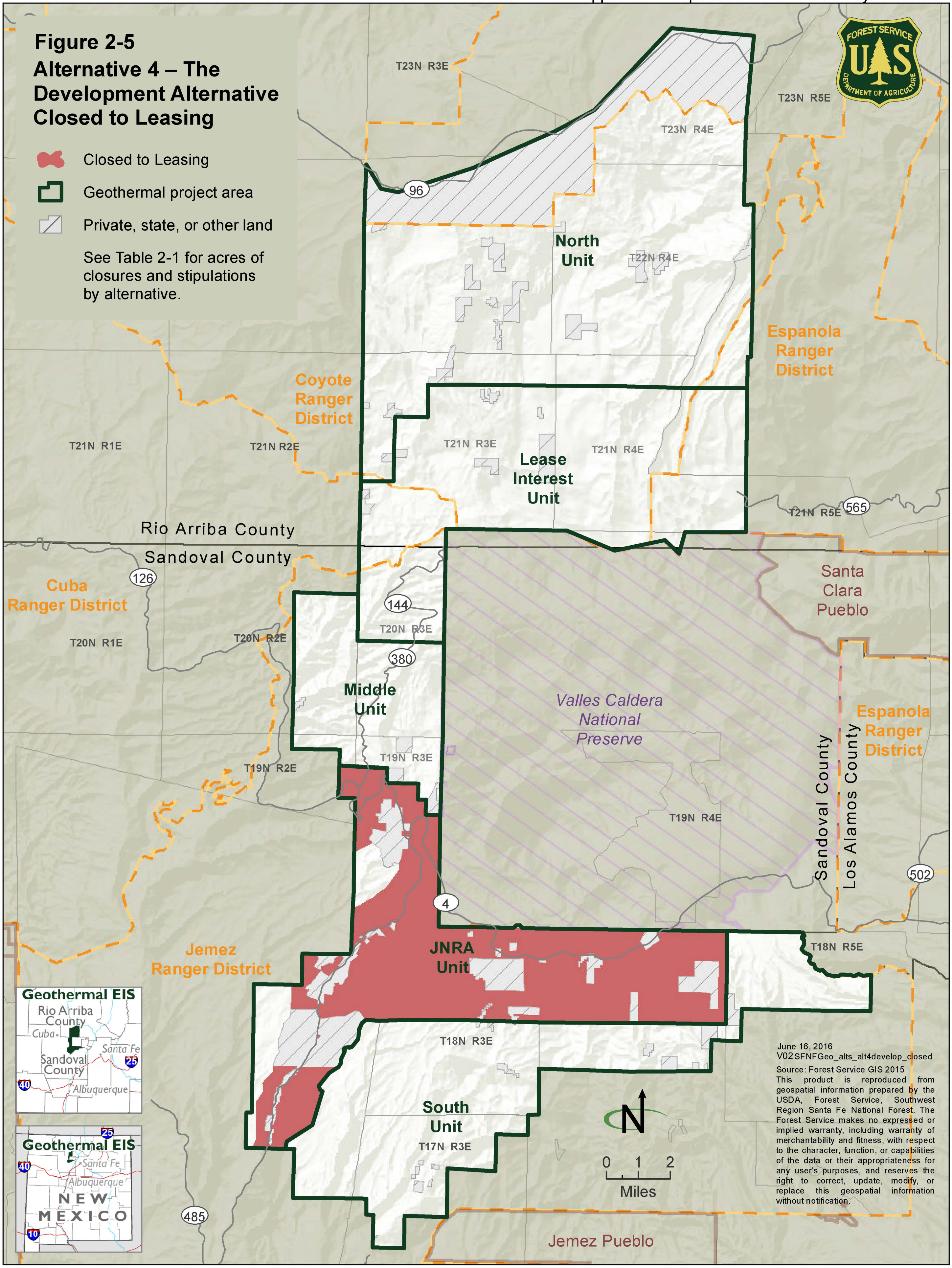

Figure 2-5
Alternative 4 – The Development Alternative Closed to Leasing
Closed to Leasing
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
T23N R4E
T23N R5E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
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565
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Miles
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
NEW MEXICO
June 16, 2016
V02SFNFGeo_alts_alt4develop_closed
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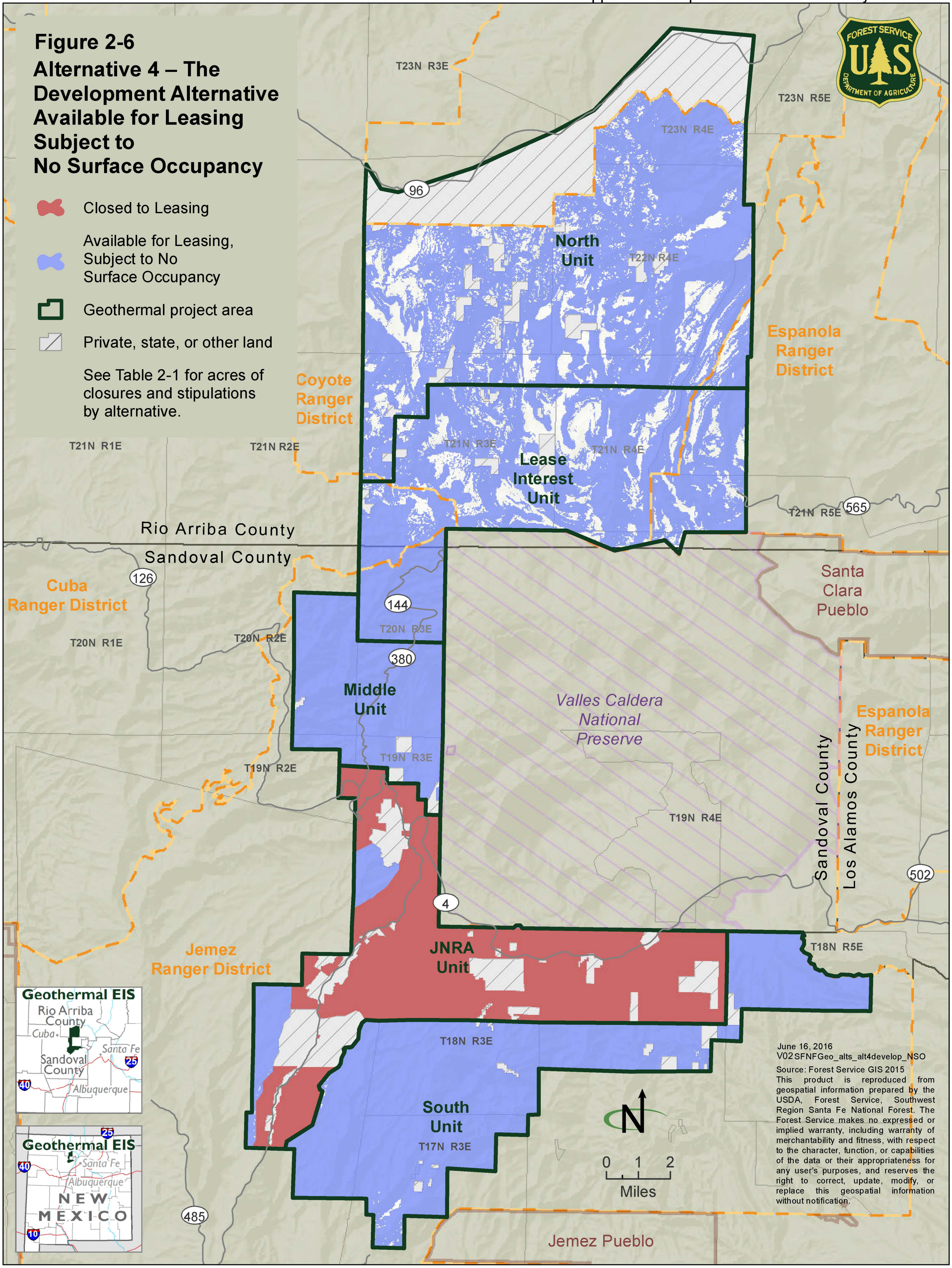
Figure 2-6
Alternative 4 – The Development Alternative Available for Leasing Subject to No Surface Occupancy
Closed to Leasing
Available for Leasing, Subject to No Surface Occupancy
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
T23N R4E
T23N R5E
T22N R4E
T21N R1E
T21N R2E
T21N R3E
T21N R4E
T21N R5E
T20N R1E
T20N R2E
T20N R3E
T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
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Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
NEW MEXICO
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Miles
June 16, 2016
V02 SFNFGeo_alts_alt4develop_NSO
Source: Forest Service GIS 2015
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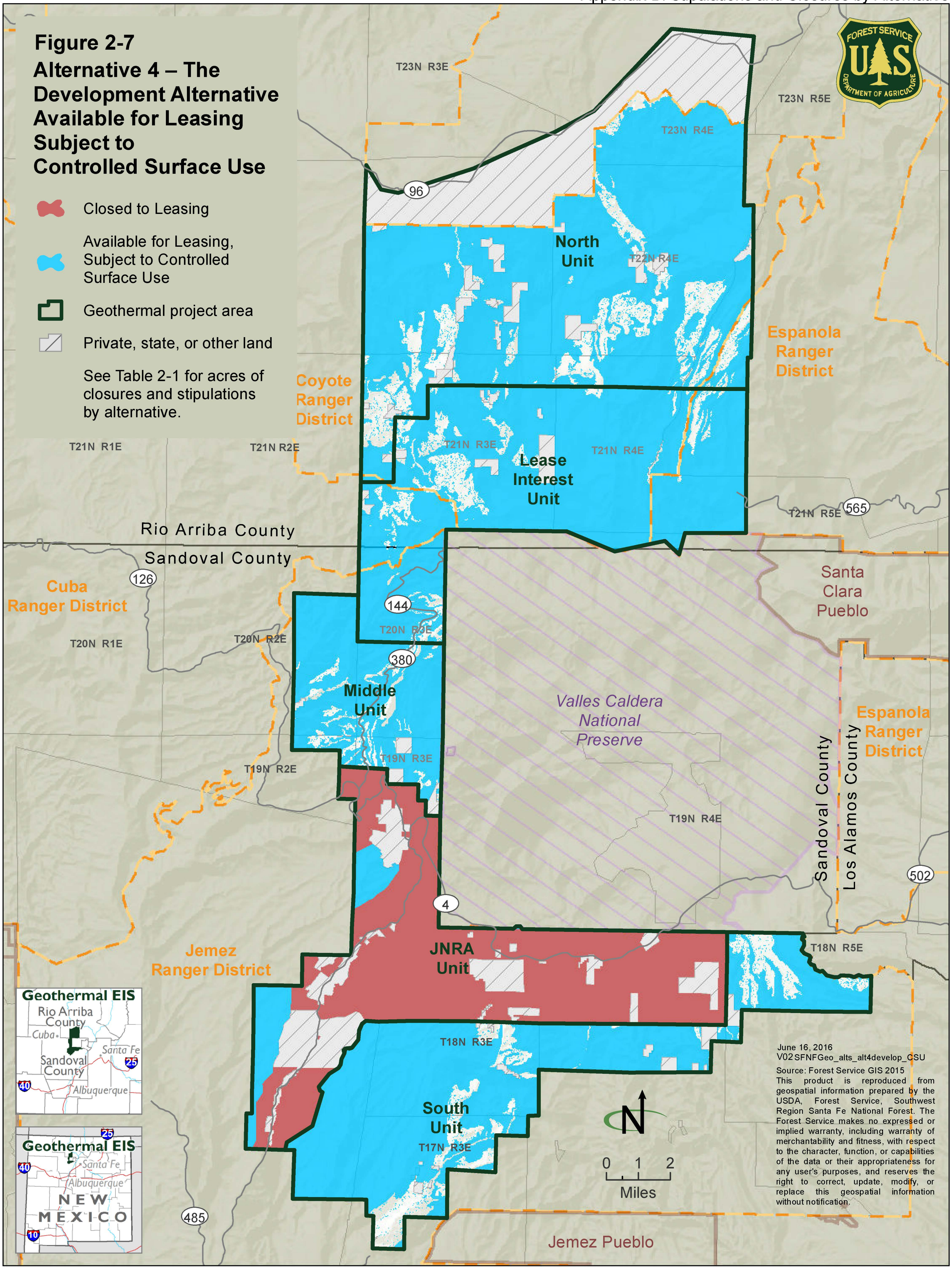
Figure 2-7
Alternative 4 – The Development Alternative Available for Leasing Subject to Controlled Surface Use
Closed to Leasing
Available for Leasing, Subject to Controlled Surface Use
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Coyote Ranger District
Espanola Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
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T19N R2E
T19N R3E
T19N R4E
T18N R3E
T18N R5E
T17N R3E
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June 16, 2016
V02 SFNFGeo_alts_alt4develop_CSU
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N
0 1 2
Miles
Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
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Geothermal EIS
Santa Fe
Albuquerque
NEW MEXICO
10

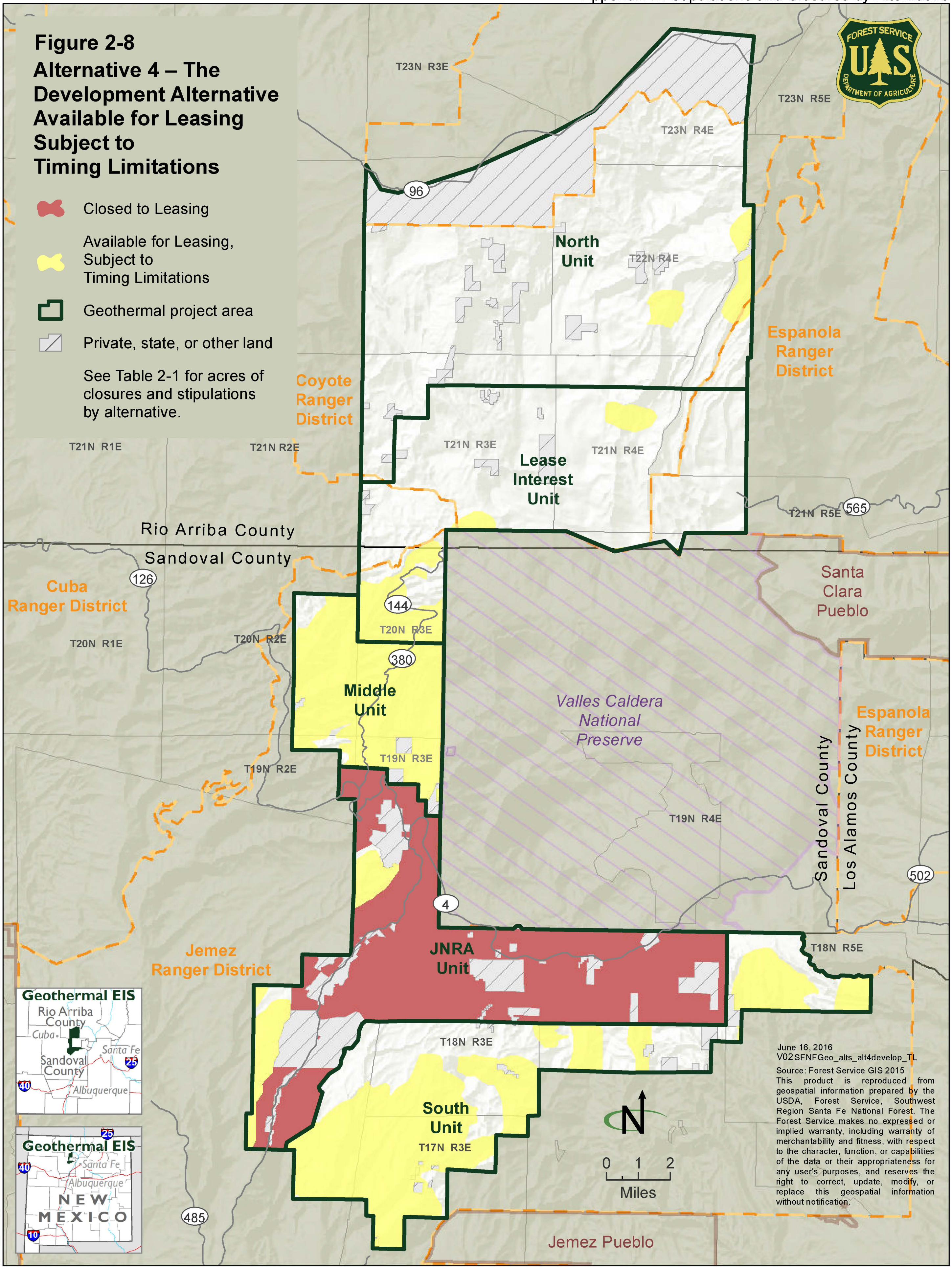
Figure 2-8
Alternative 4 – The Development Alternative Available for Leasing Subject to Timing Limitations
Closed to Leasing
Available for Leasing, Subject to Timing Limitations
Geothermal project area
Private, state, or other land
See Table 2-1 for acres of closures and stipulations by alternative.
North Unit
Lease Interest Unit
Middle Unit
JNRA Unit
South Unit
Valles Caldera National Preserve
Espanola Ranger District
Coyote Ranger District
Cuba Ranger District
Jemez Ranger District
Santa Clara Pueblo
Jemez Pueblo
Rio Arriba County
Sandoval County
Los Alamos County
T23N R3E
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T22N R4E
T21N R1E
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T20N R2E
T20N R3E
T19N R2E
T19N R3E
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T18N R3E
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Geothermal EIS
Rio Arriba County
Cuba
Santa Fe
Sandoval County
Albuquerque
Geothermal EIS
NEW MEXICO
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Miles
June 16, 2016
V02SFNFGeo_alts_alt4develop_TL
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Appendix C

Best Management Practices and Mitigation Measures

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Appendix C. Best Management Practices and Mitigation Measures

Best Management Practices (BMPs) are state-of-the-art mitigation measures applied on a site-specific basis to avoid, minimize, reduce, rectify, or compensate for adverse environmental or social impacts. They are applied to management actions to aid in achieving desired outcomes for safe, environmentally responsible resource development by preventing, minimizing, or mitigating adverse impacts and reducing conflicts.

The following BMPs provide the BLM, Forest Service, industry, and stakeholders a menu of practices for developing geothermal energy and minimizing impacts to the environment and landscape. The list is not meant to be all inclusive given the constant development of improved practices, diversity of the area, and potential for unique site-specific conditions. Practices which are not included in this appendix may be implemented as needed.

Some BMPs are more suitable for consideration on a case-by-case basis depending on:

- Their effectiveness
- The balancing of increased operating costs vs. the benefit to the public and resource values
- The availability of less restrictive mitigation alternatives that accomplish the same objective
- Other site-specific factors

Guidelines for applying and selecting project-specific requirements include determining whether the measure would:

- Ensure compliance with relevant statutory or administrative requirements
- Minimize local impacts associated with siting and design decisions
- Promote post-construction stabilization of impacts
- Maximize restoration of previous habitat conditions
- Minimize cumulative impacts
- Promote economically feasible development of geothermal energy on Forest Service land

Only those BMPs reasonably necessary to ensure environmentally responsible geothermal development should be selected from the list below. Not all of the individual mitigation measures below will apply to most situations, and selection of appropriated BMPs and mitigation measures should be dependent on factors such as the project size, location, site-specific characteristics, and potential resource impacts. Prior to inclusion, the measures may be further modified to meet site-specific situations and agency requirements.

This list was compiled from several sources, primarily:

- Programmatic EIS for Geothermal Leasing in the Western United States (2008)
- Forest Service National Best Management Practices for Water Quality Management on National Forest System Lands (2012) available at: http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf
- Forest Service Handbook (Southwestern Region) FSH 2509.22 – Soil and Water Conservation Handbook

- Santa Fe National Forest Plan (2007 as amended)

In the event that the BMPs listed here are not effective, or do not address a particular resource concern, there are numerous other sources which will be consulted. Some of these are:

- Forest Service Low-Volume Roads Engineering Best Management Practices Field Guide (2003)
- The Gold Book, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (current edition)
- BLM Washington Office Fluid Minerals website
- US DOE Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems (2012)
- US EPA
- New Mexico Game and Fish
- New Mexico Environment Department

In keeping with the PEIS, the BMPs are listed according to the phase of operations they apply to the most.

C.1 Information Collection & Monitoring

C.1.1 General

- Prior to geothermal exploration and development, a subsurface geotechnical investigation will be conducted to analyze the soil and geologic conditions of each site with proposed surface disturbance. The investigation will evaluate and identify potential geologic hazards and will provide remedial grading recommendations, foundation and slab design criteria, and soil parameters for the design of geothermal power infrastructure.
- The operator will collect available information describing the environmental and socio-cultural conditions in the vicinity of the proposed project and will provide the information to the agency.
- The agency will require suitable geotechnical or stability analyses to ensure that facilities are constructed to acceptable factors of safety using standard engineering practices and considering foundation conditions and material, construction materials and techniques, the seismicity of the area, and the water-related resources at risk.
- A monitoring program will be developed by the operator to ensure that environmental conditions are monitored during the exploration and well drilling, testing, construction, and utilization and reclamation phases. The monitoring program requirements, including adaptive management strategies, will be established at the project level to ensure that potential adverse impacts of geothermal development are mitigated. The monitoring program will identify the monitoring requirements for each major environmental resource present at the site, establish metrics against which monitoring observations can be measured, identify potential mitigation measures, and establish protocols for incorporating monitoring observations and additional mitigation measures into ongoing activities. The operator will provide results of the monitoring program to the agency in an annual report.
- The operator will comply with the Secretary of Agriculture's rules and regulations:
  - For all use and occupancy of the NFS lands prior to approval of an exploration plan by the Secretary of the Interior

- For uses of all existing improvements, such as forest development roads, within and outside the area permitted by the Secretary of the Interior
- For use and occupancy of the NFS lands not authorized by an exploration plan approved by the Secretary of the Interior

C.1.2 Paleontological and Cultural Resources

- Before any specific permits are issued under leases, treatment of cultural resources will follow the procedures established by the Advisory Council on Historic Preservation for compliance with Section 106 of the National Historic Preservation Act. A pedestrian inventory will be undertaken of all portions that have not been previously surveyed or are identified by the Forest Service or BLM as requiring inventory to identify properties that are eligible for the NRHP. Those sites not already evaluated for NRHP eligibility will be evaluated based on surface remains, subsurface testing, archival, and/or ethnographic sources. Subsurface testing will be kept to a minimum whenever possible if sufficient information is available to evaluate the site or if avoidance is an expected mitigation outcome. Recommendations regarding the eligibility of sites will be submitted to the Forest Service, and a treatment plan will be prepared to detail methods for avoidance of impacts or mitigation of effects. The Forest Service will make determinations of eligibility and effect and consult with SHPO as necessary based on each proposed lease application and project plans. In consultation with the Forest Service, the BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized, or mitigated. Avoidance of impacts through project design will be given priority over data recovery as the preferred mitigation measure. Avoidance measures include moving project elements away from site locations or to areas of previous impacts, restricting travel to existing roads, and maintaining barriers and signs in areas of cultural sensitivity. Any data recovery will be preceded by approval of a detailed research design, Native American Consultation, and other requirements for Forest Service issuance of a permit under the Archaeological Resources Protection Act.
- If cultural resources are present at the site, or if areas with a high potential to contain cultural material have been identified, a cultural resources management plan (CRMP) will be developed. This plan will address mitigation activities to be taken for cultural resources found at the site. Avoidance of the area is always the preferred mitigation option. Other mitigation options include archaeological survey and excavation (as warranted) and monitoring. If an area exhibits a high potential, but no artifacts were observed during an archaeological survey, monitoring by a qualified archaeologist could be required during all excavation and earthmoving in the high potential area. A report will be prepared documenting these activities. The CRMP also will:
  - Establish a monitoring program
  - Identify measures to prevent potential looting/vandalism or erosion impacts
  - Address the education of workers and the public to make them aware of the consequences of unauthorized collection of artifacts and destruction of property on public land
- The operator will determine whether paleontological resources exist in a project area on the basis of the sedimentary context of the area, a records search for past paleontological finds in the area, and/or, depending on the extent of existing information, a paleontological survey.
- If paleontological resources are present at the site, or if areas with a high potential to contain paleontological material have been identified, a paleontological resources management plan

will be developed. This plan will include a mitigation plan for avoidance, removal of fossils, or monitoring. If an area exhibits a high potential but no fossils were observed during survey, monitoring by a qualified paleontologist may be required during excavation and earthmoving in the sensitive area. The operator will submit a report to the agency documenting these activities. The paleontological resources management plan also will:

- Establish a monitoring program
- Identify measures to prevent potential looting/vandalism or erosion impacts
- Address the education of workers and the public to make them aware of the consequences of unauthorized collection of fossils on public land

C.1.3 Water Resources

The BMPs require suitable characterization of site hydrology commensurate with the potential for impacts to surface water and groundwater resources, to include physical and chemical characteristics of surface and groundwater systems, as needed, for the range of expected seasonal variation in precipitation and potential stormflow events likely to occur at the site for the duration of the minerals activities.

The operator will:

- Evaluate the consumptive use of water in the operation and its effect on water-dependent ecosystems.
- Evaluate the potential for direct and indirect impacts to morphology, stability, and function of waterbodies, riparian areas, and wetland habitats.
- Develop a storm water management plan for the site to ensure compliance with applicable regulations and to prevent offsite migration of contaminated storm water or increased soil erosion.
- Gain a clear understanding of the local hydrogeology. Areas of groundwater discharge and recharge and their potential relationships with surface water bodies will be identified.
- Avoid creating hydrologic conduits between two aquifers during foundation excavation and other activities.
- Identify federal, state, and local permits or requirements needed to implement the project. Examples include water quality standards, CWA 401 certification, CWA 402 permits (including stormwater permits), CWA 404 permits, and Coastal Zone Management Act requirements.
- Plan to limit surface disturbance to the extent practicable while still achieving project objectives.
- Provide adequate buffers and setbacks from waterbodies to avoid or minimize impacts to water quality and aquatic ecosystems.
- Designate specific aquatic management zones (AMZs) around water features in the project area.
- Design activities on or near unstable areas and sensitive soils to minimize management induced impacts.
- Use local direction and requirements for prevention and control of terrestrial and aquatic invasive species.

- Use suitable tools to analyze the potential for cumulative watershed effects (CWE) to occur from the additive impacts of the proposed project and past, present, and reasonably foreseeable future activities on NFS and neighboring lands within the project watersheds.
- Consider the natural sensitivity or tolerance of the watershed based on geology, climate, and other relevant factors.
- Consider the existing condition of the watershed and water quality as a reflection of past land management activities and natural disturbances.
- Estimate the potential for adverse effects to soil, water quality, and riparian resources from current and reasonably foreseeable future activities on all lands within the watershed relative to existing watershed conditions.
- Use land management plan direction; federal, state, or local water quality standards; and other regulations to determine acceptable limits for CWE.
- Modify the proposed project or activity as necessary by changing project design, location, and timing to reduce the potential for CWE to occur.
- Consider including additional mitigation measures to reduce project effects.
- Identify and implement opportunities for restoration activities to speed recovery of watershed condition before initiating additional anthropogenic disturbance in the watershed.
- Coordinate and cooperate with other federal, state, and private landowners in assessing and preventing CWE in multiple ownership watersheds.
- Integrate restoration and rehabilitation needs into the project plan.
- Consider water-quality improvement actions identified in a TMDL or other watershed restoration plan to restore impaired waterbodies within the project area.
- Identify project-specific monitoring needs.
- Document site-specific BMP prescriptions, design criteria, mitigation measures, and restoration, rehabilitation, and monitoring needs in the applicable NEPA documents, design plans, contracts, permits, authorizations, and operation and maintenance plans.
- Delineate all protected or excluded areas, including, for example, AMZs and waterbodies,
- Include 303(d) listed and TMDL waterbodies, and municipal supply watersheds, on the project map.
- Evaluate the condition of aquatic habitat, riparian habitat, and beneficial riparian zone functions and their estimated response to the proposed activity in determining the need for and width of the AMZ.
- Use stream class and type, channel condition, aspect, side slope steepness, precipitation and climate characteristics, soil erodibility, slope stability, groundwater features, and aquatic and riparian conditions and functions to determine appropriate AMZ widths to achieve desired conditions in the AMZ.
- Include riparian vegetation within the designated AMZ and extend the AMZ to include steep slopes, highly erodible soils, or other sensitive or unstable areas.
- Establish wider AMZ areas for waters with high resource value and quality.
- Design and implement project activities within the AMZ to:
    - ♦ Avoid or minimize unacceptable impacts to riparian vegetation, groundwater recharge areas, steep slopes, highly erodible soils, or unstable areas.
    - ♦ Maintain or provide sufficient ground cover to encourage infiltration, avoid or minimize erosion, and filter pollutants.

- ♦ Avoid, minimize, or restore detrimental soil compaction.
- ♦ Retain trees necessary for shading and bank stabilization, and as a future source of large woody debris.
- ♦ Retain floodplain function.
- ♦ Restore existing disturbed areas that are eroding and contributing sediment to the waterbody.

- Mark the boundaries of the AMZ and sensitive areas—like riparian areas, wetlands, and unstable areas—on the ground before land-disturbing activities.

C.1.4 Vegetation and Fish and Wildlife

- The operator will conduct surveys for plant and animal species that are listed or proposed for listing as threatened or endangered and their habitats in areas proposed for development where these species could potentially occur, following accepted protocols and in consultation with the USFWS, as appropriate. Particular care should be taken to avoid disturbing listed species during surveys in any designated critical habitat. The operator will monitor activities and their effects on ESA-listed species throughout the duration of the project.
- The operator will identify important, sensitive, or unique habitat and biota in the project vicinity and site and should design the project to avoid (if possible), minimize, or mitigate potential impacts on these resources. The design and siting of the facilities will follow appropriate guidance and requirements from the Forest Service and other resource agencies, as available and applicable.

C.1.5 National Scenic and Historic Trails

- When any ROW application includes remnants of a National Historic Trail, is located within the viewshed of a National Historic Trail's designated centerline, or includes or is within the viewshed of a trail eligible for listing on the NRHP, the operator will evaluate the potential visual impacts to the trail associated with the proposed project and identify appropriate mitigation measures for inclusion in the operation plan.

C.1.6 Air Quality and Climate

- The operator will coordinate with the New Mexico Environment Department Air Quality Bureau to develop and implement an air-quality monitoring plan.

C.2 Planning, Location, and Design

C.2.1 Bonding

- As outlined in the Forest Service Training Guide for Reclamation Bond Estimation and Administration for Minerals Plans of Operation, the Forest Service must consider the direct and indirect costs of stabilizing, rehabilitating, and reclaiming the area of mineral operations to the appropriate standards for water quality and watershed condition as determined from the land management plan, state and federal laws, regulations, plans, or permits when determining the reclamation bond amount. The bond amount determined by the Forest Service must include costs for:
  - ♦ Operation and maintenance of facilities designed to divert, convey, store, or treat water.
  - ♦ Decontaminating, neutralizing, disposing, treating, or isolating hazardous materials at the site to minimize potential for contamination of soil, surface water, and groundwater.

  - ♦ Water treatment needs predicted during planning and discovered during operations to achieve applicable water-quality standards.
  - ♦ Earthwork to reclaim roads, backfilling water features (diversions, ditches, and sediment ponds), and construction of diversion channels and drains, stream channels, and wetlands.
  - ♦ Revegetation to stabilize the site and minimize soil erosion.
  - ♦ Mitigation to restore natural function and value of streams, wetlands, and floodplains.
  - ♦ Long-term operations, monitoring, and maintenance of mineral production-related facilities that must perform as designed to avoid or minimize contamination of surface or groundwater resources, including roads, diversion ditches, dams, and water treatment systems.
  - ♦ Protection of the reclaimed area until long-term stability, erosion control, and re-vegetation has been established.
- The Forest Service coordinates with the BLM to ensure the reclamation bond required for operations will be sufficient to guarantee reclamation work on NFS lands to the appropriate standards for water quality and watershed condition as determined from the land management plan, state and federal laws, regulations, plans, or permits.

C.2.2 Traffic Planning

- The operator will consult with local planning authorities regarding increased traffic prior to the construction phase, including an assessment of the number of vehicles per day, their size, and type. Specific issues of concern (e.g., location of school bus routes and stops) will be identified and addressed in the traffic management plan.

C.2.3 Roads & Pads

- To plan for efficient use of the land, necessary infrastructure will be consolidated wherever possible.
- The operator will limit roads to the minimum practicable number, width, and total length consistent with the purpose of specific operations, local topography, geology, and climate to achieve land management plan desired conditions, goals, and objectives for access and water-quality management.
- The operator will use existing roads when practicable.
- The operator will plan road networks to have the minimum number of waterbody crossings as is practicable and necessary to achieve transportation system desired conditions, goals, and objectives.
- The operator will design the roads to maintain stable road prism, cut, and fill slopes.
- The operator will design cut and fill slope ratios to reduce soil loss from mass failures.
- The operator will use structural or nonstructural measures as necessary to stabilize cut and fill slopes.
- The operator will use brush mulches or filter fences when necessary to mitigate impacts of roads near water courses.
- The operator will design the road surface drainage system to intercept, collect, and remove water from the road surface and surrounding slopes in a manner that minimizes concentrated flow in ditches, culverts, and over fill slopes and road surfaces.

- The operator will use structural or nonstructural measures suitable to the road materials, road gradient, and expected traffic levels. The operator will use an interval between drainage features that is suitable for the road gradient, surface material, and climate.
- The operator will use suitable measures to avoid or minimize erosion of ditches.
- The operator will design and construct all new roads and drilling pads to a safe and appropriate standard, no higher than necessary to accommodate their intended use.
- Existing roads and pad sites will be used to the maximum extent feasible, but only if located in a safe and environmentally sound location. No new roads and pad sites will be constructed without agency authorization. If new roads and pad sites have been authorized, they will be designed and constructed by the operator to the appropriate agency standard, no higher than necessary to accommodate their intended function. Roads and pad sites will be routinely maintained by the operator to maintain public safety and to minimize impacts to the environment, such as erosion, sedimentation, fugitive dust, and loss of vegetation.
- An access road siting and management plan will be prepared incorporating existing agency standards regarding road design, construction, and maintenance, such as those described in the Forest Service handbook 7709.56 and the *Surface Operating Standards for Oil and Gas Exploration and Development* (i.e., the Gold Book, current edition).
- A traffic management plan will be prepared for the site access roads to ensure that no hazards would result from the increased truck traffic and that traffic flow would not be adversely impacted. This plan will incorporate measures such as informational signs, flaggers when equipment may result in blocked throughways, and traffic cones to identify any necessary changes in temporary lane configuration.
- Where possible, access roads will be located to follow natural contours and to minimize side hill cuts and fills. Excessive grades on roads, road embankments, ditches, and drainages shall be avoided, especially in areas with erodible soils.
- Roads will be designed so that changes to surface water runoff are minimized and new erosion is not initiated.
- Access roads will be located to minimize stream crossings. All structures crossing streams will be located and constructed so that they do not decrease channel stability or increase water velocity. The operator will obtain all applicable federal and state water crossing permits.
- Roads will be located away from drainage bottoms and will avoid wetlands, if practicable.
- The operator will minimize the period that disturbed areas are not vegetated by revegetating and/or mulching cuts and fill slopes.
- Clearing of vegetation along rights-of-way, facilities, and special use sites will be limited to that which poses a hazard to the facility and operational efficiency.

C.2.4 Geotechnical Analysis

- The operator will perform a detailed geotechnical analysis prior to the construction of any structures, so they will be sited to avoid any hazards from subsidence or liquefaction (i.e., the changing of a saturated soil from a relatively stable solid state to a liquid during earthquakes or nearby blasting).

C.2.5 Well Pads

The operator will:

- Locate well sites on level locations that will accommodate the intended use to reduce the need for vertical cuts and steep fill slopes.
- Use suitable measures to stabilize fill slopes and to minimize potential of slope failures.
- Use suitable measures to provide surface drainage and to manage runoff from the work areas used for mud tanks, generators, mud storage, and fuel tanks in a manner that avoids or minimizes pollutant contamination of surface waters or groundwater.
- Use nontoxic, nonhazardous drilling fluids whenever practicable.
- Construct suitable impervious containment structures with sufficient volume and freeboard to avoid or minimize spills or leakages of oil, gas, salt water, toxic liquids, or waste materials from reaching surface waters or groundwater.
- Avoid mixing of geothermal fluids with surface water or groundwater where the chemical and thermal properties of the geothermal fluids would damage aquatic ecosystems and contaminate drinking water supplies.
- Minimize production of byproducts and wastes to the extent practicable.
- Plan space to properly handle, store, and contain byproducts and wastes.
- Recycle or properly dispose of wastes (e.g., used petroleum products, site garbage, septic effluent, decommissioned equipment, and used barrels or containers).
- Use applicable practices for sanitation systems and solid waste management to avoid contaminating surface water or groundwater from sanitation or solid waste facilities.
- Manage all chemicals, reagents, fuels, and other hazardous or toxic materials used for construction and operations to avoid or minimize contaminating surface water or groundwater.
- Require a transportation spill response plan, where applicable, that describes the petroleum products or other hazardous materials or chemicals that will be used in the operations, including the routes, amount, and frequency of shipments, and the containers and vehicles that are to be used. Describe in this plan the procedures, equipment, and personnel that would be used to respond to a spill.

C.2.6 Visual Mitigation

- The operator will incorporate visual design considerations into the planning and design of the project to minimize potential visual impacts of the proposal and to meet the visual resource management objectives of the area and the agency.

C.2.6.1 Visual Design Considerations

- Construct low-profile structures whenever possible to reduce structure visibility.
- Select and design materials and surface treatments to repeat or blend with landscape elements.
- Site projects outside of the viewsheds of publically accessible vantage points, or if this cannot be avoided, as far away as possible.
- Site projects to take advantage of both topography and vegetation as screening devices to restrict views of projects from visually sensitive areas.

- Site facilities away from and not adjacent to prominent landscape features (e.g., knobs and water features).
- Avoid placing facilities on ridgelines, summits, or other locations such that they will be silhouetted against the sky from important viewing locations.
- Collocate facilities to the extent possible to use existing and shared rights-of-way, existing and shared access and maintenance roads, and other infrastructure, so they do not bisect ridge tops or run down the center of valley bottoms.
- Site linear features (aboveground pipelines, rights-of-way, and roads) to follow natural land contours rather than straight lines (particularly up slopes) when possible. Fall-line cuts should be avoided.
- Site facilities, especially linear facilities, to take advantage of natural topographic breaks (i.e., pronounced changes in slope) to avoid siting facilities on steep side slopes.
- Where available, site linear features—such as rights-of-ways and roads—to follow the edges of clearings (where they will be less conspicuous) rather than passing through the centers of clearings.
- Site facilities to take advantage of existing clearings to reduce vegetation clearing and ground disturbance, where possible.
- Site linear features (e.g., trails, roads, and rivers) to cross other linear features at right angles whenever possible to minimize viewing area and duration.
- Site and design structures and roads to minimize and balance cuts and fills and to preserve existing rocks, vegetation, and drainage patterns to the maximum extent possible.
- Use appropriately colored materials for structures or appropriate stains and coatings to blend with the project's backdrop. Refer to the Standard Environmental Colors chart available from the BLM.
- Use non-reflective or low-reflectivity materials, coatings, or paints whenever possible.
- Paint grouped structures the same color to reduce visual complexity and color contrast.
- Design and install efficient facility lighting so that the minimum amount of lighting required for safety and security is provided but not exceeded and so that upward light scattering (light pollution) is minimized. This may include, for example, installing shrouds to minimize light from straying off-site, properly directing light to only illuminate necessary areas, and installing motion sensors to only illuminate areas when necessary.
- Site construction staging areas and laydown areas outside of the viewsheds of publically accessible vantage points and visually sensitive areas, where possible, including siting in swales, around bends, and behind ridges and vegetative screens.
- Discuss visual impact mitigation objectives and activities with equipment operators prior to commencement of construction activities.
- Mulch or scatter slash from vegetation removal and spread it to cover fresh soil disturbances or, if not possible, bury or compost slash.
- If slash piles are necessary, stage them out of sight of sensitive viewing areas.
- Avoid installing gravel and pavement where possible to reduce color and texture contrasts with existing landscape.
- Use excess fill-to–fill, uphill-side swales resulting from road construction in order to reduce unnatural-appearing slope interruption and to reduce fill piles.
- Avoid downslope wasting of excess fill material.

- Round road-cut slopes, vary cut and fill pitch to reduce contrasts in form and line, and vary slope to preserve specimen trees and nonhazardous rock outcroppings.
- Leave planting pockets on slopes where feasible.
- Combine methods of reestablishing native vegetation through seeding, planting of nursery stock, transplanting of local vegetation within the proposed disturbance areas, and staging of construction-enabling direct transplanting.
- Revegetate with native vegetation establishing a composition consistent with the form, line, color, and texture of the surrounding undisturbed landscape.
- Provide benches in rock cuts to accent natural strata.
- Use split-face rock blasting to minimize unnatural form and texture resulting from blasting.
- Segregate topsoil from cut and fill activities and spread it on freshly disturbed areas to reduce color contrast and to aid rapid revegetation.
- Bury utility cables in or adjacent to the road where feasible.
- Minimize signage and paint or coat reverse sides of signs and mounts to reduce color contrast with existing landscape.
- Prohibit trash burning; store trash in containers to be hauled off-site for disposal.
- Undertake interim restoration during the operating life of the project as soon as possible after disturbances. During road maintenance activities, avoid blading existing forbs and grasses in ditches and along roads.
- Randomly scarify cut slopes to reduce texture contrast with existing landscape and to aid in revegetation.
- Cover disturbed areas with stockpiled topsoil or mulch, and revegetate with a mix of native species selected for visual compatibility with existing vegetation.
- Restore rocks, brush, and natural debris whenever possible to approximate preexisting visual conditions.

C.2.7 Air Quality and Climate

- The operator will prepare and submit to the agency an Equipment Emissions Mitigation Plan for managing diesel exhaust. The Equipment Emissions Mitigation Plan will identify actions to reduce diesel particulate, carbon monoxide, hydrocarbons, and nitrogen oxides associated with construction and drilling activities. The Equipment Emissions Mitigation Plan will require that all drilling/construction-related engines are maintained and operated as follows:
  - ♦ They are tuned to the engine manufacturer’s specification in accordance with an appropriate time frame.
  - ♦ They do not idle for more than 5 minutes (unless, in the case of certain drilling engines, it is necessary for the operating scope).
  - ♦ They are not tampered with in order to increase engine horsepower.
  - ♦ Particulate traps, oxidation catalysts, and other suitable control devices are included on all drilling/construction equipment used at the project site.
  - ♦ They use diesel fuel having a sulfur content of 15 parts per million or less, or other suitable alternative diesel fuel, unless such fuel cannot be reasonably procured in the market area.
  - ♦ They include control devices to reduce air emissions. The determination of which equipment is suitable for control devices should be made by an independent Licensed Mechanical Engineer. Equipment suitable for control devices may include drilling

equipment, work over and service rigs, mud pumps, generators, compressors, graders, bulldozers, and dump trucks.

C.2.8 Health and Safety

- The operator will use applicable practices for sanitation systems and solid waste management to avoid contaminating surface water or groundwater from sanitation or solid waste facilities.
- The operator will develop a hazardous materials management plan addressing storage, use, transportation, and disposal of each hazardous material anticipated to be used at the site. The plan will identify all hazardous materials that would be used, stored, or transported at the site. It will establish inspection procedures, storage requirements, storage quantity limits, inventory control, nonhazardous product substitutes, and disposition of excess materials. The plan will also identify requirements for notices to federal and local emergency response authorities and include emergency response plans.
- The operator will develop a waste management plan identifying the waste streams that are expected to be generated at the site and addressing hazardous waste determination procedures, waste storage locations, waste-specific management and disposal requirements, inspection procedures, and waste minimization procedures. This plan will address all solid and liquid wastes that may be generated at the site.
- The operator will develop a spill prevention and response plan identifying where hazardous materials and wastes are stored on-site, spill prevention measures to be implemented, training requirements, appropriate spill response actions for each material or waste, the locations of spill response kits on-site, a procedure for ensuring that the spill response kits are adequately stocked at all times, and procedures for making timely notifications to authorities.
- The operator will develop a transportation spill response plan that describes the petroleum products or other hazardous materials or chemicals that will be used in the operations, including the routes, amount and frequency of shipments, and containers and vehicles used. This plan will describe the procedures, equipment, and personnel that would be used to respond to a spill.
- A safety assessment will be conducted to describe potential safety issues and the means that would be taken to mitigate them, including issues such as site access, construction, safe work practices, security, heavy equipment transportation, traffic management, emergency procedures, and fire control.
- A health and safety program will be developed to protect both workers and the general public during construction and operation of geothermal projects. The program will:
    - ♦ Identify all applicable federal and state occupational safety standards
    - ♦ Establish safe work practices for each task (e.g., requirements for personal protective equipment and safety harnesses)
    - ♦ Include Occupational Safety and Health Administration standard practices for safe use of explosives and blasting agents, and measures for reducing occupational electric and magnetic fields exposures
    - ♦ Establish fire safety evacuation procedures
    - ♦ Define safety performance standards (e.g., electrical system standards and lightning protection standards)
    - ♦ Include a training program to identify hazard training requirements for workers for each task and establish procedures for providing required training to all workers.

Documentation of training and a mechanism for reporting serious accidents to appropriate agencies will be established.

- ♦ Establish a safety zone or setback for generators from residences and occupied buildings, roads, ROWs, and other public access areas that is sufficient to prevent accidents resulting from the operation of generators
- ♦ Identify requirements for temporary fencing around staging areas, storage yards, and excavations during construction or rehabilitation activities. It will also identify measures to be taken during the operation phase to limit public access to hazardous facilities (e.g., permanent fencing would be installed only around electrical substations, and facility access doors would be locked).

- The operator will consult with local planning authorities regarding increased traffic during the construction phase, including an assessment of the number of vehicles per day, their size, and type. Specific issues of concern (e.g., location of school bus routes and stops) will be identified and addressed in the traffic management plan.
- The operator will develop a fire management strategy to implement measures to minimize the potential for a human-caused fire.

C.2.9 Livestock Grazing

- The operator will coordinate with the Forest and livestock operators to minimize impacts to livestock operations.

C.2.10 Noxious Weeds and Pesticides

- The operator will develop a plan for control of noxious weeds and invasive species, which could occur as a result of new surface disturbance activities at the site. The most recent recommendations at the state and local level should be incorporated into any operating plan for the geothermal exploration and development. The plan will address monitoring, education of personnel on weed identification, the manner in which weeds spread, and methods for treating infestations. The use of certified weed-free mulching will be required. If trucks and construction equipment are arriving from locations with known invasive vegetation problems, a controlled inspection and cleaning area will be established to visually inspect construction equipment arriving at the project area and to remove and collect seeds that may be adhering to tires and other equipment surfaces.
- If pesticides are used on the site, an integrated pest management plan will be developed to ensure that applications would be conducted within the framework of all federal, state, and local laws and regulations and entail only the use of EPA-registered pesticides.

C.2.11 Vegetation and Fish and Wildlife

- The operator shall prepare a habitat restoration plan to avoid (if possible), minimize, or mitigate negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. The plan will identify revegetation, soil stabilization, and erosion reduction measures that will be implemented to ensure that all temporary use areas are restored. The plan will require that restoration occur as soon as possible after completion of activities to reduce the amount of habitat converted at any one time and to speed up the recovery to natural habitats.

C.2.12 Water Rights and Usage

The operator will:

- Obtain surface water (e.g., instream flow rights) and groundwater under appropriate federal and state legal and regulatory authorities to avoid, minimize, or mitigate adverse effects to stream processes, aquatic and riparian habitats and communities, groundwater-dependent ecosystems, and recreation and aesthetic values.
- Locate monitoring wells according to a monitoring plan to minimize the number of wells needed to achieve monitoring objectives.
- Construct and complete wells consistent with applicable federal and state regulations.
- Use licensed well drilling contractors.
- Use suitable measures to avoid or minimize well contamination, inter-aquifer exchange of water, floodwaters from contaminating the aquifer, and infiltration of surface water.
- Operate wells in such a manner as to avoid excessive withdrawals, maintain suitable groundwater levels, and minimize effects to groundwater-dependent ecosystems.
- Permanently seal abandoned wells consistent with applicable federal, state, and local regulations and requirements.
- Locate the spring box to allow water to flow by gravity from the spring to the spring box to eliminate disturbance from pumps and auxiliary equipment.
- Design the collection system to avoid, minimize, or mitigate adverse effects to the spring development and downstream waters from excessive water withdrawal, freezing, flooding, sedimentation, contamination, vehicular traffic, and livestock as needed.
- Collect no more water than is sufficient to meet the intended purpose of the spring development.
- Ensure that enough water remains in the spring to support the source groundwater-dependent ecosystem and downstream aquatic ecosystems.
- Trap and remove sediment that does enter the system.
- Intercept the spring flow below the ground surface upslope of where the water surfaces.

C.3 Construction

C.3.1 General

The operator will:

- Make adjustments in the plans, authorizations, and bonds if conditions develop that are outside the design criteria and conduct adequate notification, emergency stabilization, or other activities to avoid effects before proceeding with additional operations.
- Establish and maintain construction area limits to the minimum area necessary for completing the project and confine disturbance to within this area.
- Develop and implement an erosion control and sediment plan that covers all disturbed areas, including borrow, stockpile, fueling, and staging areas used during construction activities.
- Limit operation of equipment when ground conditions could result in excessive rutting, soil puddling, or runoff of sediments directly into waterbodies.
- Prepare a certified Spill Prevention Control and Countermeasure (SPCC) Plan for each facility as required by 40 CFR, Part 112.

- Install or construct the containment features or countermeasures called for in the SPCC Plan to ensure that spilled hazardous materials are contained and do not reach groundwater or surface water.
- Ensure that cleanup of spills and leaking tanks is completed in compliance with federal, state, and local regulations and requirements.
- Ensure that hazardous spill kits are adequately stocked with necessary supplies and are maintained in accessible locations.
- Stockpile and protect topsoil for reuse in site revegetation.
- Minimize bank and riparian area excavation during construction to the extent practicable.
- Keep excavated materials out of the waterbody.
- Use only clean, suitable materials that are free of toxins and invasive species for fill.
- Properly compact fills to avoid or minimize erosion.

C.3.2 Traffic Management

- Traffic will be restricted to the roads developed for the project. Use of other unimproved roads will be restricted to emergency situations.
- Signs will be placed along roads to identify speed limits, travel restrictions, and other standard traffic control information. Signs directing vehicles to alternative park access and parking will be posted in the event construction temporarily obstructs recreational parking areas near trailheads. Whenever active work is being performed, the area will be posted with “construction ahead” signs on any adjacent access roads or trails that might be affected.
- Project personnel and contractors will be instructed and required to adhere to speed limits commensurate with road types, traffic volumes, vehicle types, and site-specific conditions; to ensure safe and efficient traffic flow; and to reduce wildlife collisions and disturbance and fugitive dust.
- When practical, construction activities will be avoided during high recreational use periods.

C.3.3 Roads & Pads

- The operator will plan and construct, to the extent practicable, exploration roads to be recontoured when operations are complete.
- The operator will limit the extent of open exploratory areas at one time and restore one site before moving on to the next one, to the extent practicable.
- The operator will obtain agency authorization prior to borrowing soil or rock material from agency lands.
- Road use will be restricted during the wet season if road surfacing is not adequate to prevent soil displacement, rutting, and resultant stream sedimentation.
- The operator will implement suitable measures to close and physically block the road entrance so that unauthorized motorized vehicles cannot access the road.
- Access roads and on-site roads will be surfaced with aggregate materials where necessary to provide a stable road surface, support anticipated traffic, reduce fugitive dust, and prevent erosion.
- Dust abatement techniques will be used before and during surface clearing, excavation, or blasting activities. Dust abatement techniques will be used on unpaved, unvegetated surfaces to minimize fugitive dust. Speed limits (e.g., 25 mph [40 kph]) will be posted and enforced to

reduce fugitive dust. Construction materials and stockpiled soils will be covered if they are a source of fugitive dust.

- Culvert outlets will be rip-rapped to dissipate water energy at the outlet and to reduce erosion. Catch basins, roadway ditches, and culverts will be cleaned and maintained regularly.
- The operator will report all label violations that occur during the application of dust suppressants or other surface stabilizers to the appropriate enforcement agency.
- The operator will respond to and report spills and other accidents during the application of dust suppressants or other surface stabilizers.
- The operator will design and locate stream crossings to minimize disturbance to the waterbody.
- The operator will locate stream crossings where the channel is narrow, straight, and uniform, and has stable soils and relatively flat terrain to the extent practicable.
- The operator will select a site where erosion potential is low.
- The operator will orient the stream crossing perpendicular to the channel to the extent practicable.
- The operator will keep approaches to stream crossings to as gentle a slope as practicable.

C.3.4 Well Pads

The operator will:

- Locate reserve pits in stable areas on the drill pad to the extent practicable.
- Locate pits away from natural watercourses, riparian areas, wetlands, floodplains, and areas of shallow groundwater wherever practicable.
- Use suitable measures to ensure full containment of drilling fluids where the reserve pit must be placed in a sensitive location or in porous material.
- Design the reserve pit to contain all anticipated drilling muds, cuttings, fracture fluids, and precipitation while maintaining a suitable amount of freeboard to avoid or minimize overtopping.
- Use suitable measures to avoid or minimize seepage from the reserve pit contaminating groundwater.
- Remove any visible or measurable layer of oil from the surface of the reserve pit after cessation of drilling and completion of operations, and continue to keep the pit free of oil.
- Use suitable measures to avoid or minimize surface waters and groundwater from entering open pits.

C.3.5 Pipelines

- Pipelines constructed aboveground due to thermal gradient-induced expansion and contraction will rest on cradles above ground level, allowing small animals to pass underneath. Projects should be analyzed to ensure adequate passage for all wildlife species. The pipeline will be raised higher to allow wildlife passage where needed. Because pipeline corridors through certain habitat types can alter local predator/prey dynamics by providing predators with lines of sight and travel corridors, large projects should be analyzed to ensure there will be no significant changes to predator/prey balance.
- The operator will collocate pipelines and transmission lines with roads or their rights-of-way where practicable.

- The operator will limit corridor disturbance, particularly in or near AMZs, surface waters, shallow groundwater, unstable areas, hydric soils, or wetlands.
- The operator will aggressively address unauthorized uses of the corridor, such as motorized vehicle use, that are exposing soils, increasing erosion, or damaging the facilities.

C.3.6 Utilities

- Underground utilities will be installed to minimize the amount of open trenches at any given time, keeping trenching and backfilling crews close together. Avoid leaving trenches open overnight. Where trenches cannot be backfilled immediately, escape ramps should be constructed at least every 100 feet.

C.3.7 Facilities

- The BLM will request a copy of operator's Clean Water Act (CWA) 401 Certification from designated federal, state, or local entities before approving a plan of operations that may result in any discharge into waters of the United States.
- The operator will consider the following design criteria in facility planning:
  - ♦ Locate the facility away from the immediate vicinity of surface waters, AMZs, wetlands, sandy soils, shallow water tables, groundwater recharge areas, floodplains, and other sensitive areas to the extent practicable.
  - ♦ Avoid unstable slopes and soils.
  - ♦ Minimize the disturbance footprint.
- The operator will use and maintain proper erosion and sediment control practices during and immediately after construction.
- The operator will incorporate suitable stormwater controls in the project design.
- The operator will incorporate requirements from applicable federal, state, and local permits into facility construction and operation plans.
- The operator will develop a contingency plan for implementing appropriate pre-storm or winterization BMPs before the grading permit expires.
- The operator will conform to all applicable federal, state, and local regulations and permits governing water supply, sanitation, and septic systems.
- The operator will determine instream flow needs to minimize damage to scenic and aesthetic values; native plant, fish, and wildlife habitat; and to otherwise protect the environment where the operation of the facility would modify existing streamflow.
- The operator will install and seasonally monitor groundwater quality monitoring wells if a risk of groundwater pollution exists.
- The operator will establish a suitable inspection schedule to ensure that water diversion structures, conveyances, and storage facilities are performing as designed and appropriately maintained.
- The operator will maintain erosion and stormwater controls as necessary to ensure proper and effective functioning.
- The operator will prepare for unexpected failures of erosion control measures.
- The operator will implement corrective actions without delay when failures are discovered to prevent pollutant discharge to nearby waterbodies.
- The operator will routinely inspect construction sites to verify that erosion and stormwater controls are implemented and functioning as designed and are appropriately maintained.

- The operator will use suitable measures in compliance with local direction to prevent and control invasive species.

C.4 Specific Resources

C.4.1 Cultural and Paleontological Resources

- Unexpected discovery of cultural or paleontological resources during construction will be brought to the attention of the responsible BLM Authorized Officer immediately. Work will be halted in the vicinity of the find to avoid further disturbance to the resources while they are being evaluated and appropriate mitigation measures are being developed.

C.4.2 Noise

- The operator will take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project.
- Within 2 miles of existing, occupied residences, geothermal well drilling or major facility construction operations will be restricted to non-sleeping hours (7:00 am to 10:00 pm).
- All equipment will have sound-control devices no less effective than those provided on the original equipment. All construction equipment used will be adequately muffled and maintained.
- All stationary construction equipment (e.g., compressors and generators) will be located as far as practicable from nearby residences.
- If blasting or other noisy activities are required during the construction period, nearby residents will be notified by the operator at least 1 hour in advance.
- Explosives will be used only within specified times and at specified distances from sensitive wildlife or streams and lakes, as established by the federal and state agencies.

C.4.3 Noxious Weeds and Pesticides

- The use of certified, weed-free mulch will be required when stabilizing areas of disturbed soil.
- If trucks and construction equipment are arriving from locations with known invasive vegetation problems, a controlled inspection and cleaning area will be established to visually inspect construction equipment arriving at the project area and to remove and collect seeds that may be adhering to tires and other equipment surfaces.
- Fill materials and road surfacing materials that originate from areas with known invasive vegetation problems will not be used.
- Revegetation, habitat restoration, and weed control activities will be initiated as soon as possible after construction activities are completed.
- Use of pesticides must be approved by the agency. Pesticide use will be limited to agency-approved pesticides and will only be applied in accordance with label and application permit directions and stipulations for terrestrial and aquatic applications.

C.4.4 Waste Management

- The operator will plan for suitable equipment refueling and servicing sites during project design.

- All refueling will occur in a designated fueling area that includes a temporary berm to limit the spread of any spill.
- Drip pans will be used during refueling to contain accidental releases.
- Drip pans will be used under fuel pump and valve mechanisms of any bulk fueling vehicles parked at the construction site.
- Any containers used to collect liquids will be enclosed or screened to prevent access to contaminants by wildlife, livestock, and migratory birds.
- Spills will be immediately addressed per the spill management plan, and soil cleanup and removal will be initiated as soon as feasible.
- The operator will use nontoxic, nonhazardous drilling fluids whenever practicable.
- The operator will construct suitable impervious containment structures with sufficient volume and freeboard to avoid or minimize spills or leakages of oil, gas, salt water, toxic liquids, or waste materials from reaching surface waters or groundwater.

C.4.5 Wildlife

- The operator will ensure that employees, contractors, and site visitors avoid harassment and disturbance of wildlife, especially during reproductive (i.e., courtship and nesting) seasons. In addition, pets will be controlled or excluded to avoid harassment and disturbance of wildlife.
- Ponds, tanks, and impoundments (including but not limited to drill pits) containing liquids can present hazards to wildlife. Any liquids contaminated by substances which may be harmful due to toxicity, or fouling of the fur or feathers (detergents and oils), should be excluded from wildlife access by fencing, netting, or covering at all times when not in active use. Liquids at excessive temperature should likewise be excluded. If exclusion is not feasible, such as a large pond, a hazing program based on radar or visual detection, in conjunction with formal monitoring, should be implemented. Clean water impoundments can also present a trapping hazard if they are steep-sided or lined with smooth material. All pits, ponds, and tanks should have escape ramps functional at any reasonably anticipated water level, down to almost empty. Escape ramps can take various forms depending on the configuration of the impoundment. Earthen pits may be constructed with one side sloped 3:1 or greater lined ponds can use textured material; straight-sided tanks can be fitted with expanded metal escape ladders.

C.4.6 Air Quality

- Use of any dust suppressant must be specifically authorized by the Forest Service. The operator must consider the following when requesting the authorization to use dust suppressants:
  - ♦ Select chemical products suitable for use on the target species or that meet project objectives.
  - ♦ Use chemicals that are registered for the intended uses.
  - ♦ Consult the Materials Safety Data Sheet and product label for information on use, hazards, and safe handling procedures for chemical products under consideration for use.
  - ♦ Consider chemical solubility, absorption, breakdown rate properties, and site factors when determining which chemical products to use.
  - ♦ Use chemicals with properties such that soil residual activity will persist only as long as needed to achieve treatment objectives.

- ♦ Consider soil type, chemical mobility, distance to surface water, and depth to groundwater to avoid or minimize surface water and groundwater contamination.
- ♦ Use a suitable pressure, nozzle size, and nozzle type combination to minimize off-target drift or droplet splatter.
- ♦ Specify management direction and appropriate site-specific response measures in project plans and safety plans (FSH 2109.14, chapter 60).
- ♦ Ensure that planned chemical use projects conform to all applicable local, state, federal, and agency laws, regulations, and policies.
- ♦ Obtain necessary permits, including CWA 402 permit coverage.
- ♦ Develop spill contingency plans.
- ♦ Obtain or provide training and licensing as required by the label and state regulations.
- ♦ Incorporate constraints identified on the label and other legal requirements of application into project plans and contracts.
- ♦ Be aware that states may have more restrictive requirements than the label instructions.

C.5 Operations/Utilization

C.5.1 General

- "Good housekeeping" procedures will be developed by the operator to ensure that during all phases of exploration and operation the site will be kept clean of noxious weeds, debris, litter, garbage, fugitive trash or waste, and graffiti. Scrap heaps and dumps are prohibited. Storage yards are to be minimized to that which is absolutely necessary.
- The operator will make adjustments in the plans, authorizations, and bonds if conditions develop that are outside the design criteria and conduct adequate notification, emergency stabilization, or other activities to avoid effects before proceeding with additional operations.
- The operator will inspect drainage structures and road surfaces after major storm events and perform any necessary maintenance.

C.6 Roads

The operator will:

- Maintain the road surface drainage system to intercept, collect, and remove water from the road surface and surrounding slopes in a manner that reduces concentrated flow in ditches, culverts, and over fill slopes and road surfaces.
- Conduct frequent inspections to ensure road drainage is not adversely affecting soil or water resources.
- Clean ditches and catch basins only as needed to keep them functioning.
- Move snow in a manner that will avoid or minimize disturbance of or damage to road surfaces and drainage structures.
- Mark drainage structures to avoid damage during plowing.
- Discontinue road use and snow removal when use would likely damage the roadway surface or road drainage features.
- Modify snow removal procedures as necessary to meet water quality concerns.

- Replace lost road surface materials with similar quality material and repair structures damaged in snow removal operations as soon as practicable.

C.6.1 Chemical Transport and Storage

The operator will:

- Transport and handle chemical containers in a manner that minimizes the potential for leaks and spills.
- Inspect containers for leaks or loose caps or plugs before loading.
- Secure containers properly to avoid or minimize shifting in transport.
- Check containers periodically en route.
- Ensure arrangements for proper storage are in place before transporting chemicals.
- Manage and store chemicals in accordance with all applicable federal, state, or local regulations, including label directions.
- Store chemicals in their original containers with labels intact.
- Locate chemical storage facilities at sites that minimize the possibility of impacts to surface water or groundwater in case accidents or fires occur.
- At a minimum, ensure that containment of a complete spill from the largest container being stored is possible with the spill-kit materials at the storage site.
- Check containers before storage and periodically during storage to ensure that they are properly sealed and not leaking.

C.6.2 Produced Water

The operator will:

- Discharge or otherwise dispose of produced water in compliance with the CWA and Safe Drinking Water Act, with appropriate approvals from the State and EPA.
- Reinject produced water of suitable quality into acceptable underground reservoirs when authorized and appropriate.
- Avoid, minimize, or mitigate surface-discharge effects including headcuts, stream crossing washouts, impoundments, channel stability, and flooding.

C.7 Reclamation

- A reclamation plan meeting the following objectives and standards will be submitted prior to site development:

  Reclamation Objectives

  - ♦ The objective of <u>interim reclamation</u> is to restore vegetative cover and a portion of the landform sufficient to maintain healthy, biologically active topsoil; control erosion; and minimize habitat, visual, and forage loss during the life of the well or facilities.
  - ♦ The long-term objective of <u>final reclamation</u> is to return the land to a condition approximating that which existed prior to disturbance. This includes restoration of the landform and natural vegetative community, hydrologic systems, visual resources, and wildlife habitats. To ensure that the long-term objective will be reached through human and natural processes, actions will be taken to ensure standards are met for site stability, visual quality, hydrological functioning, and vegetative productivity.

Reclamation Performance Standards

Interim Reclamation – Includes disturbed areas that may be redisturbed during operations and will be redisturbed at final reclamation to achieve restoration of the original landform and a natural vegetative community. It will be judged successful when the authorized officer determines that disturbed areas not needed for active, long-term production operations or vehicle travel have been recontoured, protected from erosion, and revegetated with a self-sustaining, vigorous, diverse, native (or as otherwise approved) plant community sufficient to minimize visual impacts, provide forage, stabilize soils, and impede the invasion of noxious, invasive, and non-native weeds.

Final Reclamation – Includes disturbed areas where the original landform and a natural vegetative community have been restored. It will be judged successful when the authorized officer determines that the original landform has been restored for all disturbed areas including well pads, production facilities, roads, pipelines, and utility corridors.

- ♦ A self-sustaining, vigorous, diverse, native (or otherwise approved) plant community is established on the site, with a density sufficient to control erosion and invasion by non-native plants and to reestablish wildlife habitat or forage production. At a minimum, the established plant community will consist of species included in the seed mix and/or desirable species occurring in the surrounding natural vegetation.
- ♦ No single species will account for more than [to be determined by site-specific survey] percent of the total vegetative composition unless it is evident at higher levels in the adjacent landscape.
- ♦ Permanent vegetative cover will be determined successful when the basal cover of desirable perennial species is at least [to be determined by site-specific survey] percent of the basal cover on adjacent or nearby undisturbed areas where vegetation is in a healthy condition.
- ♦ Plants must be resilient as evidenced by well-developed root systems and flowers. Shrubs will be well established and in a “young” age class at a minimum; therefore, they will not be comprised mainly of seedlings that may not survive until the following year.
- ♦ Erosion features are equal to or less than the surrounding area, and erosion control is sufficient so that water naturally infiltrates into the soil and gullying, headcutting, slumping, and deep or excessive rills (greater than 3 inches) are not observed.
- ♦ The site is free of state- or county-listed noxious weeds, oil field debris and equipment, and contaminated soil. Invasive and nonnative weeds are controlled.

C.7.1 Reclamation Actions

- During initial well pad, production facility, road, pipeline, and utility corridor construction and prior to completion of the final well on the well pad, pre-interim reclamation stormwater management actions will be taken to ensure disturbed areas are quickly stabilized to control surface water flow and to protect both the disturbed and adjacent areas from erosion and siltation. This may involve construction and maintenance of temporary silt ponds, silt fences, berms, ditches, and mulching.
- When the last well on the pad has been completed, some portions of the well location will undergo interim reclamation and some portions of the well pad will usually undergo final reclamation. Most well locations will have limited areas of bare ground, such as a small area around production facilities or the surface of a rocked road. Other areas will have interim reclamation where workover rigs and tanks may need a level area to set up in the future.

Some areas will undergo final reclamation where portions of the well pad will no longer be needed for production operations and can be recontoured to restore the original landform.

The following minimum reclamation actions will be taken to ensure that the reclamation objectives and standards are met. It may be necessary to take additional reclamation actions beyond the minimum in order to achieve the Reclamation Standards.

C.7.2 Reclamation – General

- The agency will be notified 24 hours prior to commencement of any reclamation operations.
- The operator will sample and test the site to identify hazardous materials and associated areas that may be contaminated by petroleum products, reactive materials, or other chemicals.
- The operator will use suitable measures to isolate, neutralize, remove, or treat hazardous or contaminated materials—including chemicals, reactive materials, acidic wastes, fuels, pit fluids, sediment, and human waste—consistent with applicable federal, state, and local regulations to achieve applicable standards.
- The operator will properly abandon, plug, and cap all drill holes, cores, and wells per applicable state or federal requirements.
- The operator will reconstruct, maintain, or decommission roads, trails, and staging areas consistent with the land management plan's desired conditions, goals, and objectives for the area.
- The operator will use suitable measures to limit human, vehicle, and livestock access to the site as needed to allow for recovery of vegetation.

C.7.2.1 Housekeeping

- Immediately upon well completion, the well location and surrounding areas(s) will be cleared of, and maintained free of, all debris, materials, trash, and equipment not required for production.
- No hazardous substances, trash, or litter will be buried or placed in pits. Upon well completion, any hydrocarbons in the pit will be remediated or removed.

C.7.2.2 Vegetation Clearing

- Vegetation removal and the degree of surface disturbance will be minimized wherever possible.
- During vegetation-clearing activities, trees and woody vegetation removed from the well pad and access road will be moved aside prior to any soil-disturbing activities. Care will be taken to avoid mixing soil with the trees and woody vegetation.
- Trees left for wood gathering will be cut and delimbed. Trunks 6 inches or more in diameter will be removed and placed either by the uphill side of the access road, moved to the end of the road, or moved to a road junction for easy access for wood gatherers and to reduce vehicle traffic on the well pad. Trees with a trunk diameter less than 6 inches and woody vegetation will be used to trap sediment or slow runoff, or they will be scattered on reclaimed areas to stabilize slopes, control erosion, and improve visual resources.

C.7.2.3 Topsoil Management

- Operations will disturb the minimum amount of surface area necessary to conduct safe and efficient operations. When possible, equipment will be stored and operated on top of vegetated ground to minimize surface disturbance.

- In areas to be heavily disturbed, the top (to be determined by a site-specific survey) inches of soil material will be stripped and stockpiled around the perimeter of the well location to control run-on and run-off, and to make redistribution of topsoil more efficient during interim reclamation. Stockpiled topsoil may include vegetative material. Topsoil will be clearly segregated and stored separately from subsoils.
- Earthwork for interim and final reclamation will be completed within 6 months of well completion or plugging unless a delay is approved in writing by the BLM Authorized Officer.
- Salvaging and spreading topsoil will not be performed when the ground or topsoil is frozen or too wet to adequately support construction equipment. If such equipment creates ruts in excess of 4 inches deep, the soil will be deemed too wet.
- No major depressions will be left that would trap water and cause ponding.

C.7.2.4 Seeding

- Initial seedbed preparation will consist of recontouring to the appropriate interim or final reclamation standard. All compacted areas to be seeded will be ripped to a minimum depth of 18 inches with a minimum furrow spacing of 2 feet, followed by recontouring the surface and then evenly spreading the stockpiled topsoil. Prior to seeding, the seedbed will be scarified and left with a rough surface.
- If broadcast seeding is to be used and is delayed, final seedbed preparation will consist of contour cultivating to a depth of 4 to 6 inches within 24 hours prior to seeding, dozer tracking, or other imprinting in order to loosen up the soil and create seed germination micro-sites.
- Seed application will be conducted no more than 24 hours following completion of final seedbed preparation.
- A certified weed-free seed mix designed by the Forest Service and BLM to meet reclamation standards will be used on all disturbed surfaces, including pipelines and road cut and fill slopes.
- The application rate (to be determined by site-specific survey) is based on drill-seeded to a depth of 0.25 to 0.5 inches, which is the method that will be used where feasible.
- Shrub species will be seeded during the winter on the ground surface or preferably on top of snow.
- In areas that will not be drill-seeded, the seed mix will be broadcast-seeded at twice the application rate shown in the table and covered no more than 0.25 inch deep with a harrow, drag bar, or roller or will be broadcast-seeded into imprints, such as fresh dozer cleat marks.
- Seeding will be done in (season to be determined by site-specific survey).

C.7.2.5 Erosion Control and Mulching

- Mulch, silt fencing, wattles, hay bales, and other erosion control devices will be used on areas at risk of soil movement from wind and water erosion.
- Mulch will be used if necessary to control erosion, create vegetation micro-sites, and retain soil moisture and may include hay, small-grain straw, wood fiber, live mulch, cotton, jute, or synthetic netting. Mulch will be free from mold, fungi, and certified free of noxious or invasive weed seeds.
- If straw mulch is used, it will contain fibers long enough to facilitate crimping and to provide the greatest cover.

C.7.2.6 Pit Closure

- Reserve pits will be closed and backfilled within 60 days of release of the rig. All reserve pits remaining open after 60 days will require written authorization of the authorized officer. Immediately upon well completion, any hydrocarbons or trash in the pit will be removed. Pits will be allowed to dry, be pumped dry, or solidified in-situ prior to backfilling.
- Following completion activities, pit liners will be completely removed or removed down to the solids level and disposed of at an approved landfill, or treated to prevent their reemergence to the surface and interference with long-term successful revegetation. If it was necessary to line the pit with a synthetic liner, the pit will not be trenched (cut) or filled (squeezed) while containing fluids. When dry, the pit will be backfilled with a minimum of 5 feet of soil material. In relatively flat areas, the pit area will be slightly mounded above the surrounding grade to allow for settling and to promote surface drainage away from the backfilled pit.

C.7.2.7 Management of Invasive, Noxious, and Non-Native Species

- All reclamation equipment will be cleaned prior to use to reduce the potential for introduction of noxious weeds or other undesirable non-native species.
- An intensive weed monitoring and control program will be implemented prior to site preparation for planting and will continue until interim or final reclamation is approved by the authorized officer.
- Monitoring will be conducted at least annually during the growing season to determine the presence of any invasive, noxious, and non-native species. Invasive, noxious, and non-native species that have been identified during monitoring will be promptly treated and controlled.

C.7.3 Interim Reclamation Procedures – Additional

C.7.3.1 Recontouring

- Interim reclamation actions will be completed no later than 6 months from when the final well on the location has been completed, weather permitting. The portions of the cleared well site not needed for active operational and safety purposes will be recontoured to the original contour if feasible, or if not feasible, to an interim contour that blends with the surrounding topography as much as possible. Sufficient semi-level area will remain for setup of a workover rig and to park equipment. In some cases, rig anchors may need to be pulled and reset after recontouring to allow for maximum interim reclamation.
- If the well is a producer, the interim cut and fill slopes prior to reseeding will not be steeper than a 3:1 ratio, unless the adjacent native topography is steeper. Note: Constructed slopes may be much steeper during drilling but will be recontoured to the above ratios during interim reclamation.
- Roads and well production equipment will be placed on location so as to permit maximum interim reclamation of disturbed areas. If equipment is found to interfere with the proper interim reclamation of disturbed areas, the equipment will be moved so proper recontouring and revegetation can occur.

C.7.3.2 Application of Topsoil & Revegetation

- Topsoil will be evenly respread and aggressively revegetated over the entire disturbed area not needed for all-weather operations, including road cuts and fills and to within a few feet of the production facilities, unless an all-weather, surfaced, access route or small “teardrop” turnaround is needed on the well pad.

- In order to inspect and operate the well or complete workover operations, it may be necessary to drive, park, and operate equipment on restored, interim vegetation within the previously disturbed area. Damage to soils and interim vegetation will be repaired and reclaimed following use. To prevent soil compaction, under some situations, such as the presence of moist, clay soils, the vegetation and topsoil will be removed prior to workover operations and restored and reclaimed following workover operations.

C.7.3.3 Visual Resources Mitigation for Reclamation

- Trees, if present, and vegetation will be left along the edges of the pads whenever feasible to provide screening.
- To help mitigate the contrast of recontoured slopes, reclamation will include measures to feather cleared lines of vegetation and to save and redistribute cleared trees, debris, and rock over recontoured cut and fill slopes.
- To reduce the view of production facilities from visibility corridors and private residences, facilities will not be placed in visually exposed locations (such as ridgelines and hilltops).
- Production facilities will be clustered and placed away from cut slopes and fill slopes to allow the maximum recontouring of the cut and fill slopes.
- All long-term, aboveground structures will be painted (color to be determined by site-specific survey; from the “Standard Environmental Colors” chart) to blend with the natural color of the late-summer landscape background.

C.7.4 Final Reclamation Procedures – Additional

- Final reclamation actions will be completed within 6 months of well plugging, weather permitting.
- All disturbed areas, including roads, pipelines, pads, facilities, and interim reclaimed areas will be recontoured to the contour existing prior to initial construction or a contour that blends indistinguishably with the surrounding landscape. Resalvaged topsoil will be respread evenly over the entire disturbed site to ensure successful revegetation. To help mitigate the contrast of recontoured slopes, reclamation will include measures to feather cleared lines of vegetation and to save and redistribute cleared trees, woody debris, and large rocks over recontoured cut and fill slopes.
- Water breaks and terracing will only be installed when absolutely necessary to prevent erosion of fill material. Water breaks and terracing are not permanent features and will be removed and reseeded when the rest of the site is successfully revegetated and stabilized.
- If necessary to ensure timely revegetation, the pad will be fenced to exclude livestock grazing for the first two growing seasons or until seeded species become firmly established, whichever comes later.
- Final abandonment of pipelines and flowlines will involve flushing and properly disposing of any fluids in the lines. All surface lines and any lines that are buried close to the surface that may become exposed in the foreseeable future due to water or wind erosion, soil movement, or anticipated subsequent use, must be removed. Deeply buried lines may remain in place unless otherwise directed by the authorized officer.

C.7.4.1 Road Closure

The operator will:

- Remove drainage structures.
- Recontour and stabilize cut slopes and fill material.
- Reshape the channel and streambanks at crossing sites to pass expected flows without scouring or ponding, minimize potential for undercutting or slumping of streambanks, and maintain continuation of channel dimensions and the longitudinal profile through the crossing site.
- Restore or replace streambed materials to a particle-size distribution suitable for the site.
- Restore floodplain function.
- Implement suitable measures to promote infiltration of runoff and intercepted flow and desired vegetation growth on the road prism and other compacted areas.
- Use suitable measures in compliance with local direction to prevent and control invasive species.

C.7.4.2 Reclamation Monitoring and Final Abandonment Approval

- Reclaimed areas will be monitored annually. Actions will be taken to ensure that reclamation standards are met as quickly as reasonably practical.
- Reclamation monitoring will be documented in an annual reclamation report submitted to the authorized officer by (date to be determined). The report will document compliance with all aspects of the reclamation objectives and standards, identify whether the reclamation objectives and standards are likely to be achieved in the near future without additional actions, and identify actions that have been or will be taken to meet the objectives and standards. The report will also include acreage figures for:
    - ♦ Initial Disturbed Acres
    - ♦ Successful Interim Reclaimed Acres
    - ♦ Successful Final Reclaimed Acres

Annual reports will not be submitted for sites approved by the authorized officer in writing as having met interim or final reclamation standards. Monitoring and reporting continues annually until interim or final reclamation is approved. Any time 30 percent or more of a reclaimed area is redisturbed, monitoring will be reinitiated.

- The authorized officer will be informed when reclamation has been completed, appears to be successful, and the site is ready for final inspection.

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