GRC Transactions, Vol. 42, 2018

Environmental Concerns and Mitigation Associated with Geothermal Resource Confirmation Drilling Activities

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Keywords

Environment, Exploration, Resource Confirmation, Drilling, Regulation, Permitting, NEPA

ABSTRACT

In 2017–2018, the Bureau of Land Management's National Renewable Energy Coordination Office, through its Geothermal Program, funded the National Renewable Energy Laboratory (NREL) to analyze technical and environmental considerations related to geothermal resource confirmation drilling. NREL solicited input from a group of technical and environmental experts in the geothermal industry, along with analyzing National Environmental Policy Act of 1969 (NEPA) documentation for previously approved projects. The collected data and analysis will be used by the Bureau of Land Management to examine the possibility of developing a new classification of wells and/or expediting the NEPA compliance process, which could potentially reduce permitting and regulatory compliance timelines when compared to the current process for obtaining a geothermal drilling permit for resource confirmation drilling activities.

1. Introduction

Geothermal drilling has high up-front costs and high potential risk of unsuccessful exploration efforts, making it difficult to secure financing for these projects before the resource has been confirmed. As a result, the Bureau of Land Management's (BLM) National Renewable Energy Coordination Office, through its Geothermal Program, funded the National Renewable Energy Laboratory (NREL) to analyze technical and environmental considerations related to geothermal resource confirmation drilling. For the purposes of this paper, geothermal resource confirmation drilling can be defined as "obtaining sufficient subsurface information that proves with high probability that a resource of a certain magnitude can be developed." When a developer has confirmed a resource, financial institutions are more willing to provide financing for further phases of project development, including the wellfield and power plant. The resource confirmation phase is distinct from and follows the resource exploration phase. Geothermal exploration uses various techniques—such as interpreting geologic maps, analyzing surface manifestations, conducting seismic and resistivity surveys, and drilling core holes and

temperature-gradient wells—to find geothermal resources (43 CFR § 3250 et seq., Stober and Bucher, 2013; Glassley, 2014). Once a promising region has been identified, larger-size wells are drilled, and additional tests are conducted (as discussed in Section 3) to confirm the resource.

This analysis reviews technical requirements and environmental concerns for geothermal resource confirmation that will be used by the BLM to examine the possibility of developing a new classification of wells and/or expediting National Environmental Policy Act of 1969 (NEPA) compliance. The new well classification or expedited NEPA compliance could potentially reduce permitting and regulatory compliance timelines when compared to the current process for obtaining a geothermal drilling permit (GDP) for resource confirmation drilling activities.

As part of this analysis, NREL conducted a series of technical and environmental interviews with geothermal stakeholders (i.e., Geothermal Expert Team) to understand the minimum technical requirements for confirming a geothermal resource, the associated potential environmental concerns, and measures to mitigate these concerns. As a follow-up to the one-on-one interviews with geothermal stakeholders, NREL organized a series of monthly teleconferences with the Geothermal Expert Team to gain consensus on the feedback documented as part of the one-on-one interviews. In addition, NREL held an in-person workshop in February 2018, inviting a broader industry audience, during the Stanford Geothermal Workshop in Palo Alto, CA. Following completion of the interviews, monthly teleconferences, and in-person workshop, NREL staff reviewed 21 NEPA documents (see Appendix A) related to geothermal exploration and resource confirmation drilling to capture additional insight on the environmental concerns and mitigation measures from previous projects.

The following sections provide a summary of: 1) our methodology, 2) background information on NEPA and BLM geothermal permitting requirements, 3) basic technical requirements to confirm a geothermal resource, and 4) environmental concerns and associated mitigation measures from expert interviews and previous NEPA documents.

2. Methodology

In 2017, NREL staff identified technical and environmental experts in the geothermal industry to provide insight on the technical requirements and associated environmental concerns for geothermal resource confirmation drilling. For additional information on the technical interview criteria and technical members of the Geothermal Expert Team, see Beckers and Young 2018.

Environmental experts interviewed included representatives from the U.S. Department of Energy, BLM, environmental consulting firms, and geothermal project developers. Interviews with environmental members of the Geothermal Expert Team posed a series of questions concerning environmental concerns and associated mitigation measures related to geothermal resource confirmation drilling for the following categories:

- Site Access (e.g., road construction, transportation of equipment and personnel to the drill site)
- Drill Site (e.g., well pads, sumps/pits, material storage)
- Water Quality, Discharge, and Use

- Safety
- Timing for Plugging and Abandoning a Well
- Noise, Light, and Proximity to Population.

Upon completion of the environmental interviews, NREL staff held a teleconference with the environmental members of the Geothermal Expert Team to review feedback provided during the one-on-one interviews and obtain consensus on environmental concerns and mitigation measures. The results of the interviews and teleconference were then presented to a broader audience during a workshop held in Palo Alto, CA, during the 2018 Stanford Geothermal Workshop. The workshop provided a venue to verify the previously collect data and seek additional input from an international audience of geothermal professionals. Following the Palo Alto workshop, NREL staff circulated a draft memo to attendees and Geothermal Expert Team members to confirm the provided input was captured accurately.

Upon completion of the geothermal stakeholder engagement, NREL reviewed and analyzed NEPA documents—Environmental Assessments (EAs) and Findings of No Significant Impact (FONSIs)—for geothermal exploration drilling/resource confirmation drilling projects. Previous geothermal projects were selected based a review of the Regulatory and Permitting Information Desktop (RAPID) Toolkit's Geothermal NEPA Database and input from the Geothermal Expert Team.

3. The National Environmental Policy Act of 1969

Signed into law on January 1, 1970, NEPA requires federal agencies or departments to consider the environmental impacts of all major federal actions significantly affecting the quality of the human environment (NEPA, Sec. 102). NEPA is predominately a procedural tool through which a federal agency or department considers the environmental impacts of a proposed action and analyzes alternatives to a proposed action before making a final decision.

Generally, federal agencies use three types of reviews for compliance with NEPA, depending on the specific major federal action:

1. Categorical Exclusion (CX)
2. Environmental Assessment (EA)
3. Environmental Impact Statement (EIS).

3.1 Categorical Exclusion

The Council on Environmental Quality (CEQ) NEPA regulations define a *categorical exclusion* as "a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations and for which, therefore neither an environmental assessment nor an environmental impact statement is required" (40 CFR § 1508.4)

The BLM currently has one CX specific to geothermal exploration, which allows the BLM to use a CX for the approval of a Notice of Intent (NOI) to conduct geophysical exploration pursuant to 43 CFR § 3250, when no temporary or new road construction is proposed (516 DM 11 (6)). NOIs under 43 CFR § 3250 permit exploration operations, which include geophysical operations, drilling temperature-gradient wells, drilling holes used for explosive charges for seismic exploration, core drilling, and other drilling methods as long as the operations do not directly test, produce, or utilize the geothermal resource (43 CFR § 3200.1). In addition, the NOI permits the construction of new roads; however, the applicable CX does not allow new road construction (43 CFR 3200.1). As such, resource confirmation drilling projects reviewed for this analysis are not eligible for a CX under current BLM regulations.

Although BLM staff is authorized to use the CX when approving an NOI meeting the above-mentioned requirements, the BLM is not required to use the CX, and under certain circumstances may choose to complete an EA. The presence of extraordinary circumstances may prevent the BLM from using the CX and require the completion on an EA if the activity would have a significant impact on the human environment. Extraordinary circumstances are a list of activities that the BLM (or other federal agencies) must consider that may cause significant environmental effects (see Levine and Young 2014). The BLM list of *extraordinary circumstances* includes factors such as having a significant impact on public health and safety, environmentally sensitive areas such as wild and scenic rivers or national monuments, endangered species or their critical habitat, or historic properties and sacred Indian sites. The mere presence of an extraordinary circumstance within the project site does not prevent the use of a CX, but project impacts on the extraordinary circumstance generally requires at least the completion of an EA.

Previous analysis of BLM geothermal CX processing timeframes has shown that the process for completing a CX review takes about two months (Young et al. 2014).

3.1.1 Guidance on Developing New or Revised Categorical Exclusions

NEPA established the CEQ to oversee and assist in implementing the NEPA process and other requirements as enumerated in the Act (NEPA § 201). The CEQ has provided guidance on how to establish new or revised categorical exclusions under NEPA (Sutley 2010). The CEQ guidance provides mechanisms for substantiating new or revised categorical exclusions, including:

1. A review of previously implemented actions, including monitoring and evaluating "the effects of previously implemented actions that were analyzed in EAs and consistently supported Findings of No Significant Impact"
2. Impact demonstration projects
3. Information from professional staff, outside expert opinions, and scientific analyses
4. Benchmarking other agencies' experience with a comparable CX (Sutley 2010).

3.2 Environmental Assessment

The CEQ NEPA regulations define an environmental assessment as "a concise public document for which a Federal agency is responsible that serves to:

1. Briefly provide sufficient evidence and analysis for determining whether to prepare an EIS or FONSI.

2. Aid an agency's compliance with [NEPA] when no EIS is necessary.
3. Facilitate preparation of an [environmental impact] statement when one is necessary" (40 CFR §1508.9).

Where the BLM completes an EA but does not find the potential for a significant impact on the quality of the human environment, the BLM issues a FONSI and may proceed with permit approval. A FONSI is "a document by a Federal agency briefly presenting the reasons why an action, not otherwise excluded, will not have a significant effect on the human environment and for which an environmental impact statement therefore will not be prepared" (40 CFR § 1508.13). For purposes of this analysis, all of the projects reviewed completed an EA and resulted in a FONSI.

Previous analysis of BLM geothermal EA processing timeframes has shown that the process for completing an EA review takes about 10 months (Young et al. 2014).

3.3 Environmental Impact Statement

NEPA defines an *environmental impact statement* as "A detailed [written] statement…on —

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed action,
(iv) the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.
NEPA § 102(2)(C)

Projects reviewed for this analysis did not rise to the level of requiring an EIS (in general, resource confirmation drilling activities do not require completing an EIS). However, other geothermal activities—e.g., wellfield, power plant, and/or transmission line development—may require completing an EIS.

Previous analysis of BLM geothermal EIS processing timeframes has shown that the process for completing an EIS review takes about 25 months (Young et al. 2014).

4. Environmental Concern and Mitigation Findings from Interviews, Teleconferences, and Workshop

Environmental interview feedback was predominately based on the technical requirement assumptions for geothermal resource confirmation drilling provided by technical members of the Geothermal Expert Team. As further discussed in Beckers and Young 2018, the analysis showed that confirming a geothermal resource requires confirming reservoir temperature, chemistry, permeability, and flow rate. Obtaining these data requires drilling at least two—and preferably three—successful wells into the resource to conduct the necessary tests including an interference test. Bottom-hole well diameters of at least 6" to 8" (0.15 to 0.2 m) are needed to achieve the

necessary flow rates. Drilling these wells requires a drill rig with mud pump and derrick capable of holding three drill pipes. This type of drill rig requires a minimum well pad size of 2.5 acres (10^4 m^2) including surface area for a 1 million-gallon (3.8 million-liter) pit. Up to 15 acres (5×10^4 m^2) of total surface disturbance are needed for developing access roads and well pads to drill a total of three to five wells.

The remainder of this section reviews the environmental concern and mitigation feedback provided by environmental members of the Geothermal Expert Team for each of the categories discussed in Section 2. The information collected was designed, in part, to address CEQ guidance on CXs discussed above and was gathered from professional staff, outside experts, and through scientific analyses.

Note that the commonly applied mitigation measures are **not intended to serve as requirements** for future geothermal resource confirmation drilling activities. Instead, these mitigation measures are illustrative and serve to show that potential environmental concerns associated with geothermal resource confirmation drilling typically are known and that addressing these concerns is fairly standardized.

4.1 Site Access: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with accessing a geothermal resource confirmation drilling site:

- The presence of cultural, tribal, or paleontological resources; sensitive species and/or critical habitat (including migration corridors), and environmentally sensitive areas (e.g., wetlands, wild and scenic rivers) along the access route.
- The presence of creek crossings, which may impact endangered species and waters of the United States and/or give rise to state water resource issues.
- The spread of noxious weeds and/or invasive species.
- Access routes that include unstable road slopes, which will require extensive cut and fill to stabilize the road.
- The length of road in place and level (quality) of the road, which may require new road construction or upgrades to existing roads.
- Suitable drainage for roads to prevent flash flooding and storm-water runoff.
- Ruts caused by equipment on the roads during rain events, particularly in arid climates, which could last years after the road dries up.
- Fugitive dust emissions from transporting personnel and equipment along the access route.
- Construction of permanent roads, which the public will use for recreational purposes, leading to increased traffic in the area.
- Greenhouse gas emissions from vehicles accessing the site.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or

conditions of approval (for a drilling permit) to reduce environmental concerns associated with accessing a geothermal resource confirmation drilling site:

- Complete a "desk review" to avoid any known cultural resources, sensitive species and/or critical habitat, and environmentally sensitive areas.
- Complete an on-site review (if necessary) based on findings from a "desk review," including findings related to the granularity and certainty of existing surveys.
- Lay down temporary mats/pads to protect sagebrush routes or similar environmental concerns along the access route.
- Power-wash all construction equipment prior to arrival at the drill site to prevent transportation of noxious weeds into the project area.
- Inspect and treat employee clothing and shoes to prevent the spread of noxious weeds into the project area.
- Employ standard dust-suppression strategies to prevent fugitive dust emissions, including the use of water and/or magnesium chloride along the access road.
- Reclaim roads constructed to access the drill site.
- Comply with local air-quality requirements for vehicle emissions.

4.2 Drill Site: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with a geothermal resource confirmation drilling site:

- The presence of cultural, tribal, or paleontological resources; sensitive species and/or critical habitat (including migration corridors), and environmentally sensitive areas (e.g., wetlands, wild and scenic rivers) at the drill site and along access routes between individual well pads located at the drill site.
- Terrestrial and avian species getting into a well or sump.
- Avian species (including eagles and other raptors) nesting/perching on drill rig towers, which may create a competitive advantage and threaten existing prey.
- The spread of noxious weeds and/or invasive species.
- The corrosiveness of and/or hazardous constituents in geothermal fluid and the potential for sump overflow to contaminate the surrounding area.
- The length of time the sump will be utilized and how long fluid will remain in the sump.
- Grading of land, which may destroy vegetation and displace species.
- Digging a cellar (e.g., hole) for the blowout preventer.
- Erosion occurring at the drill site.
- New material being brought into the drill site (e.g., road mix gravel).

- Cumulative and connected impacts generally, including ancillary construction activities and pipelines.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or conditions of approval (for a drilling permit) to reduce environmental impacts associated with accessing a geothermal resource confirmation drilling site:

- Complete a "desk review" to avoid any known cultural resources, sensitive species and/or critical habitat, and environmentally sensitive areas.
- Complete an on-site review (if necessary) based on findings from a "desk review," including findings related to the granularity and certainty of existing surveys.
- Establish seasonal restraints for breeding and migration.
- Place fencing around sump and grate over wellbore to protect humans/species.
- Place netting over or rubber balls in sump to prevent avian species from entering.
- Place escape ladders in sump for humans/species to exit and/or make the sump shallower in one end to allow for easier exit for species (i.e., "beach approach").
- Place mats for vegetation at the drill site, particularly in wet climates to help avoid need for a Clean Water Act Section 404 permit.
- Power-wash all construction equipment prior to arrival at project site to prevent transportation of noxious weeds into drill site/project area.
- Inspect and treat employee clothing and shoes to prevent the spread of noxious weeds into the drill site/project area.
- Limit/prevent new material being brought into the drill site without specific environmental analysis.

4.3 Water Quality, Discharge, and Use: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with water quality, water discharge, and water use during geothermal resource confirmation drilling:

- Effects to plant and animal species from briny, salty, corrosive, or scalding (hot) geothermal fluids.
- Source of water use (e.g., Where does the water come from? Is the withdrawal sustainable? Does the water require pipelines to the well pad? Is the water hauled to the site in tanker trucks?).
- Sump overflow and potential contaminants in the sump fluids.
- Leaching of sump fluid into the soil, potentially impacting the shallow drinking water table (if one exists).
- Creation of unstable slopes.
- Safe water discharge to natural drainages while avoiding erosion.

- Leaking or spilling tanks (if tank storage is utilized), particularly due to disconnecting hoses from storage tank.
- Spills associated with the drill rig that are not noticed until taking the drill rig off of the drill pad.
- Use of toxic drilling muds.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or conditions of approval (for a drilling permit) to reduce environmental impacts associated with water quality, discharge, and use during geothermal resource confirmation drilling:

- Use of liners for sumps/pits (clay or ethylene propylene diene monomer rubber [EPDM]) if shallow groundwater is present.
- Use of separate pits for geothermal brine (large pit) and drill cuttings (small pit).
- Maintain 2 feet of freeboard to prevent sump overflow (freeboard height potentially changes based on sump dimensions, particularly depth).
- Case well to beneath the potable-water-quality aquifer (if one exists).
- Place impermeable (removable) protection under the rig to facilitate clean-up.
- Use water-based and non-toxic geothermal drilling fluids.
- Revegetate slopes to stabilize slopes.
- Reinject geothermal fluids or use storage tanks (as opposed to long-term storing on surface in sumps).[1]

4.4 Safety: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with safety during geothermal resource confirmation drilling:[2]

- Improper storage of fuels or hazardous materials.
- Release of H_2S (where applicable).
- Fires.
- Well blowout.
- Dangers (e.g., human contact) resulting from very high-temperature geothermal fluids.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or

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[1] A small sump for drilling mud, drill cuttings, etc., may always be necessary, but this can avoid the need for a larger sump.

[2] Note that the principal concern is based on the engineering of the well; the NEPA process does not matter if the well is not designed properly. Therefore, permit review for the GDP is more important to the safety aspect.

conditions of approval (for a drilling permit) to reduce environmental impacts associated with safety concerns during geothermal resource confirmation drilling:

- Add containment around stored fuels and hazardous materials.
- Use H_2S monitoring devices at drill site and potentially on drilling personnel.
- Place danger signs to warn about fluid temperature and H_2S.
- Ensure adequate well design to control well and prevent blowout.
- Store fire safety equipment at the drill site.
- Plan an emergency escape/evacuation route.
- Use a blowout preventer.
- Wear protective clothing.

4.5 Noise, Light, and Proximity to Population: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with noise, light, and proximity to population during geothermal resource confirmation drilling:

- Generally, limited concerns due to the temporary activity that is associated with the drill rig, which is only at the drill site for a couple of weeks.
- Noise and light impacts for specific species.
- Noise related to transporting equipment and personnel to the site, 24-hour drilling, and well testing may impact species or nearby populations.
- Small levels of induced seismicity that may impact nearby populations.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or conditions of approval (for a drilling permit) to reduce environmental impacts associated with noise, light, and proximity to population during geothermal resource confirmation drilling:

- Use sound barriers or blankets.
- Shield light downward.
- Place time and seasonal restrictions on drilling to protect species and nearby populations.

4.6 Plugging and Abandoning Wells: Environmental Concerns and Mitigation Measures

The following is a list of potential ***environmental concerns*** associated with the timing for plugging and abandoning wells used for geothermal resource confirmation:[3]

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[3] Some members of the Geothermal Expert Team suggested that plugging and abandoning a well in a specific amount of time may not be an environmental concern as long as the company is diligently pursuing development on the lease.

- The site stays un-reclaimed for an extended period of time.
- Liner degradation may cause water quality impacts.
- Impacts to groundwater quality.
- Could cause more environmental impacts by plugging and abandoning a well than leaving it in place on an active project site, particularly if the developer plans to revisit and continue work.

The following is a list of potential ***mitigation measures*** that project developers commonly utilize or the BLM may incorporate as mitigation measures in a NEPA document, best practices, or conditions of approval (for a drilling permit) to reduce environmental impacts associated with plugging and abandoning a well during geothermal resource confirmation drilling:

- Provide sufficient bonding amount to cover the cost of reclamation.
- Ensure conditions of approval aimed at limiting the time period and well safety during that time period.

5. NEPA Geothermal Resource Confirmation Drilling Review and Analysis

As part of the environmental concern and mitigation analysis, NREL staff reviewed NEPA documents (EA/FONSI) related to 21 previously approved geothermal exploration and resource confirmation drilling projects (see Appendix A for a list of NEPA documents for reviewed projects). The review was used to: 1) capture additional insight on and validate the Geothermal Expert Team's feedback on the environmental concerns and mitigation measures for geothermal resource confirmation drilling, as well as 2) align with CEQ CX guidance on reviewing previously implemented actions, including monitoring and evaluating "the effects of previously implemented actions that were analyzed in EAs and consistently supported Findings of No Significant Impact."

NREL staff catalogued basic project information related to the project's location, required BLM permits, the planned exploration drilling and geothermal resource confirmation activities, the size and number of wells and well pads, and the total estimated surface disturbance. In addition, NREL staff catalogued environmental concerns and mitigation measures for species (e.g., endangered and threatened species, migratory birds, wild horses and burros, invasive/nonnative species), vegetation and soils, environmentally sensitive areas (e.g., wetlands, wilderness areas, wilderness study areas), cultural resources, water quality and use, air quality, safety, noise and visual impacts.

NEPA documents (EA/FONSI) used in this analysis were published between 2005 and 2014 and were chosen with the intent of gathering a broad scope of resource confirmation drilling scenarios. Projects occurred in California, Nevada, Oregon, and Utah on public lands (in some cases extending into private land) and the surface was managed by either the BLM or the U.S. Forest Service. The area of direct impact caused by the proposed actions (i.e., projects) ranged in size from 3.7 acres up to 620 acres of total surface disturbance, with a mean of 92 acres and

median of 69.8 acres. As a sub-set, surface disturbance from new or upgraded access roads fell between 0 and 146 acres, with a mean and median of 20.7 and 12.7 acres respectively.[4] The analyzed projects proposed between 1 to 27 well pads, with a mean of 12.2 well pads and a median of 12.5 well pads, while the total number of wells ranged from 3 to 60, with a mean and median of 28.9 and 33 wells respectively.[5]

The remainder of this section provides illustrative examples of some of the most significant environmental concerns observed for each of these categories and the mitigation measures used to reduce the overall impact on the environment and resources.

5.1 Species

The projects reviewed for this analysis did not include any federally listed threatened or endangered species known to be present and potentially impacted in the project area (although some state-listed species were present). However, many of the projects reviewed did include potential impacts to migratory birds. The most common impact observed was a loss of habitat (either temporarily or permanently) resulting from project activities, including vegetation removal that impacted nesting and breeding, or contributed to direct mortality.

5.1.1 Tungsten Mountain Geothermal Exploration Project – Migratory Bird Impacts

The Tungsten Mountain Geothermal Exploration Project in Churchill County, Nevada, proposed to drill and test up to 27 wells on 27 separate well pads requiring BLM approval of GDPs and completion of an EA (BLM 2012). The EA identified about 131 acres of total surface disturbance, including 113.4 acres for well pads, 12.7 acres for access roads, and 5 acres for additional pit construction (BLM 2012). The EA identified about 131 acres of direct habitat loss for migratory birds in the area. Nevertheless, the EA noted that the amount of acreage lost was small relative to the hundreds of thousands of acres of available habitat in the project vicinity, and the population viability for any individual migratory bird species was not expected to be in jeopardy due to project construction or operation.

5.1.2 Tungsten Mountain Geothermal Exploration Project – Migratory Bird Mitigation Measures

To effectively mitigate the potential impact on migratory bird mortality and breeding, mitigation measures included suggesting (but not requiring) project activities occur outside of the migratory bird season (May 15 to July 15). If project activities were to occur during migratory bird season, a qualified biologist would need to conduct bird surveys for nesting species prior to construction. Further, if an active nest was identified during the study, a “no-activity” buffer of 200 feet would be established until the nest becomes inactive (BLM 2012).

5.2 Vegetation and Soils

Generally, impacts to soil and vegetation were a direct result of ground-disturbing activities (e.g., construction of access roads and well pads) that would remove vegetation and soil, resulting in the potential erosion of soils due to increased exposure to wind and water. In addition, control of

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[4] Total surface disturbance included well pads, access roads, pipelines and buffer zones.
[5] Analyzed wells included temperature gradient wells (TGW), exploration wells (slim and full size), resource confirmation wells, observation wells, and production and injection wells.

non-native species and noxious weeds were a concern for the disturbed areas in which vegetation was removed.

5.2.1 Dixie Meadows Geothermal Exploration Project – Vegetation and Soils Impacts

The Dixie Meadows Geothermal Exploration Project in Churchill County, Nevada, proposed to drill and test up to 60 wells on 20 well pads requiring BLM approval of NOIs and GDPs and the completion of an EA (BLM 2011). The EA identified a maximum of about 137 acres of surface disturbance, of which 57 acres would occur in areas where vegetation cover was generally absent. As a result, the EA identified about 80 acres where the project would impact existing vegetation cover, representing about 14% of the vegetation cover in the project area. In addition to the direct impacts of vegetation removal, the EA also noted the potential for cleared areas to become susceptible to the spread of invasive vegetation (BLM 2011a).

5.2.2 Dixie Meadows Geothermal Exploration Project – Vegetation and Soils Mitigation Measures

To effectively mitigate the potential impact on vegetation and soils, mitigation measures included salvaging topsoil, which would reduce the effects of soil compaction during reclamation, as well as the use of certified weed-free seed mixes during reclamation. The EA noted that implementing reclamation of the project area would occur within two years of project completion (BLM 2011a).

5.3 Environmentally Sensitive Areas

The projects reviewed for this analysis did not take place in a wilderness area or wilderness study area. However, a few of the projects reviewed did have wetlands within the project area. Wetlands may be impacted by resource exploration through erosion and sedimentation, groundwater withdrawal, and leaks and spills of project-related hazardous materials (e.g., drilling mud and additives, petroleum products and emissions, and geothermal fluid).

5.3.1 Glass Buttes Geothermal Exploration Project – Environmentally Sensitive Area Impacts

The Glass Buttes Geothermal Exploration Project in Burns, Oregon, proposed to drill 13 exploratory wells[6] (3 slim wells, 10 full-diameter wells) on 13 well pads requiring NOIs and GDPs and the completion of an EA. The EA identified about 59 acres of surface disturbance on BLM-managed public lands and 13 acres on adjacent private land (BLM 2011b). The EA noted that the project area included up to 60.36 acres of potential wetlands based on the National Wetland Inventory and USGS National Hydrography Database (BLM 2011b).

5.3.2 Glass Buttes Geothermal Exploration Project – Environmentally Sensitive Area Mitigation Measures

The Glass Buttes Geothermal Exploration Project EA noted that the wetlands located within the project area would not experience disturbance due to project activities (road and well-pad construction). As a result, the EA did not include any mitigation measures for wetland impacts (BLM 2011b).

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[6] The project proposal also included drilling up to three wells on private land.

5.4 Cultural Resources

Cultural resources may be difficult to identify at the outset of a geothermal project. A cultural inventory can identify known cultural and historic resources in the project area; however, subsurface discoveries of previously unidentified cultural resources may occur during project activities. In addition, geothermal resource exploration and resource confirmation has the potential to affect a site's eligibility for the National Register of Historic Places if not conducted responsibly.

5.4.1 McCoy II Geothermal Exploration Project – Cultural Resources Impacts

The McCoy II Geothermal Exploration Project in Churchill County, Nevada, proposed to drill up to 57 wells (temperature-gradient wells, observation wells, and full-diameter wells) on 19 well pads. The EA identified a maximum total surface disturbance of 69 acres, including about 30 acres for road improvement and 39 acres for well pads (BLM 2011c). In furtherance of the project, a cultural resources inventory was conducted that evaluated 20 sites and 16 isolates. The EA noted that project construction could affect some of the cultural sites having National Register of Historic Places eligibility, which would constitute a significant impact. However, the EA stated that most of the proposed activities within the project area were located away from the eligible sites and historic properties (BLM 2011c).

5.4.2 McCoy II Geothermal Exploration Project – Cultural Resources Mitigation Measures

To effectively mitigate the potential impact on cultural resources in the project area, the EA listed a series of mitigation measures, including:

- Avoid known eligible or potentially eligible cultural resource sites during construction and operation.
- Establish a 100-foot buffer zone around eligible or potentially eligible cultural resource sites.
- Engineer the project area to avoid run-off that could affect adjacent cultural resources.
- Where project activities could impact cultural resources, retain a qualified archaeologist to serve as a cultural monitor during construction.
- Limit vehicle travel to established roads within the project area.
- Cease all operations upon discovery of any cultural resources and notify the BLM field manager.

5.5 Water Quality and Use

Generally, geothermal exploration and resource confirmation drilling projects may include impacts to both surface water and groundwater as well as require some level of water consumption. Although these impacts are typically temporary and localized, more severe impacts can occur as a result of well blowout, accidental release of hazardous materials to the environment, and disturbance or alteration of the subsurface aquifers.

5.5.1 Salt Wells Geothermal Drilling Project – Water Quality and Use Impacts

The Salt Wells Geothermal Drilling Project in Churchill County, Nevada, proposed to drill up to ten 8.5-inch-diameter wells, on 10 well pads requiring an NOI and, if a productive resource was

discovered, proposed drilling full-size wells requiring a GDP and the completion of an EA (BLM 2007). The EA identified a maximum surface disturbance of 56 acres, including 38 acres for well pads and 18 acres for access roads if the developer implemented the full proposal, including drilling full-size wells. Surface water impacts included the potential for flooding, the release/runoff of substances used in the construction process (e.g., fuels and hydraulic fluid), and pipe or storage-tank rupture affecting water quality. In addition, noted groundwater impacts included decreasing the local groundwater aquifer through proposed use of a water well and groundwater quality impacts if cooling-water evaporation ponds recharge shallow groundwater (BLM 2007).

5.5.2 Salt Wells Geothermal Drilling Project – Water Quality and Use Mitigation Measures

To effectively mitigate the potential impacts on surface water and groundwater in the project area, the EA included a series of mitigation measures. For surface-water impacts, the EA provided containment and cleanup standards for spills of substances, a stormwater pollution prevention program as required under the Clean Water Act, and proper maintenance and monitoring of pipes and storage tanks to avoid ruptures. For groundwater impacts, the EA stated that groundwater withdrawals would be limited based on county temporary water-use permits to avoid permanent adverse effects on the groundwater aquifer, and a National Pollution Discharge Prevention System permit would require the developer to demonstrate that cooling-water discharges would not degrade groundwater quality (BLM 2007).

5.6 Safety

Safety concerns included fire prevention and H_2S monitoring. In addition, exploratory and resource confirmation drilling involves the use of equipment that creates sparks (e.g., welding equipment, vehicles), which increases the potential for fires within the project area and may spread to surrounding areas.

5.6.1 Steamboat Geothermal Wells Project – Safety-Related Impacts

The Steamboat Geothermal Wells Project in Washoe County, Nevada, proposed to drill three wells (temperature-gradient well, observation well, and production well) from one well pad requiring a GDP and the completion of an EA (BLM and USFS 2014). The EA identified a maximum surface disturbance of 3.7 acres, including 2.8 acres for the well pad and 0.9 acre for road improvement. The EA noted a potential safety concern related to fires occurring at the drill site (BLM and USFS 2014).

5.6.2 Steamboat Geothermal Wells Project – Safety-Related Mitigation Measures

To effectively mitigate potential impacts caused by fires, the EA listed safety measures, including:

- Small fires occurring at the drill site should be controlled by drill rig personnel using on-site firefighting equipment.
- The developer should notify the BLM district office immediately of any wildfire.
- All vehicles and drill sites would need a shovel, 5 gallons of water, and a fire extinguisher.

- Catalytic converters on vehicles would be inspected often and cleaned of all flammable debris.
- Cutting and welding should occur in an area free or mostly free of vegetation.
- Compliance with BLM fire restrictions or closures.
- Smoking would be permitted only in designated areas (BLM and USFS 2014).

5.7 Noise and Visual Impacts

Noise and visual impacts (e.g., light, drill rig) may have impacts on both nearby human populations as well as species inhabiting the area. General impacts noted in projects reviewed for this analysis included noise from construction equipment, viewshed impacts, and use of lights when drilling at night.

5.71. Coyote Canyon/Dixie Meadows Geothermal Exploration Projects – Noise and Visual Impacts

The Coyote Canyon/Dixie Meadows Geothermal Exploration Projects in Churchill County, Nevada, proposed to drill up to 60 wells (temperature-gradient wells, observation wells, and production wells) on 20 well pads (BLM 2011d). The maximum total surface disturbance was 137 acres, including a maximum well-pad disturbance of 82 acres and nearly 35 acres for access roads. The EA noted several visual impacts, including temporary visual impacts related to the drill rig and use of lights to drill at night. The EA did not include any potential noise impacts (BLM 2011d).

5.7.2 Coyote Canyon/Dixie Meadows Geothermal Exploration Projects – Noise and Visual Impacts Mitigation Measures

To effectively mitigate the potential impacts caused by visual impacts to viewsheds, the EA listed mitigation measures, including:

- All drill rigs and well test facility lights would be limited to those required to safely conduct operations.
- All drill rig and well test facility lights should be shielded or directed in a manner to focus direct light on the immediate work area.
- Removal of equipment upon completion of drilling and testing the wells (BLM 2011d).

6. Conclusion

This analysis reviewed environmental concerns and mitigation measures for geothermal resource confirmation drilling activities to provide the BLM with background information to identify potential areas for reducing regulatory compliance and permitting timelines. Table 1 highlights findings of this analysis from the interviews, group teleconferences, an in-person workshop, and previous NEPA environmental review documents.

Table 1: Summary of Environmental Concerns and Mitigation Measures

Site Access			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• The presence of cultural, tribal, or paleontological resources; sensitive species and/or critical habitat, and environmentally sensitive areas along the access route. • The spread of noxious weeds and/or invasive species. • Fugitive dust emissions from transporting personnel and equipment along the access route.	• Complete a "desk review" to avoid any known cultural resources, sensitive species and/or critical habitat, and environmentally sensitive areas. • Complete an on-site review based on findings from a "desk review." • Power-wash all construction equipment prior to arrival at the drill site and inspect and treat employee clothing and shoes to prevent transportation of noxious weeds. • Employ standard dust-suppression strategies to prevent fugitive dust emissions.	The McCoy II Geothermal Exploration Project EA noted that project construction could affect some of the cultural sites having National Register of Historic Places eligibility, which would constitute a significant impact. However, the EA stated that most of the proposed activities within the project area are located away from the eligible sites and historic properties.	The EA lists the following mitigation measures: • Avoid known eligible or potentially eligible cultural resource sites during construction and operation. • Establish a 100-foot buffer zone around eligible or potentially eligible cultural resource sites. • Engineer the project area to avoid run-off that could affect adjacent cultural resources. • Where project activities could impact cultural resources, retain a qualified archaeologist to serve as a cultural monitor during construction. • Limit vehicle travel to established roads within the project area. • Cease all operations upon discovery of any cultural resources and notify the BLM field manager.
Drilling Site			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• Terrestrial and avian species getting into a well or sump. • The corrosiveness of and/or hazardous constituents in geothermal fluid and the potential for sump overflow to contaminate the surrounding area. • Grading of land, which may destroy vegetation and displace species. • Cumulative and connected impacts generally, including	• Establish seasonal restraints for breeding and migration. • Place grate over wellbore. Use fencing around, escape ladders in, and netting over sump to protect humans and terrestrial/avian species. • Place mats for vegetation at the drill site, particularly in wet climates to help avoid need for a Clean Water Act Section 404	The Tungsten Mountain Geothermal Exploration Project EA identified 131 acres of habitat loss for migratory birds in the area but noted that the habitat lost was small relative to the available habitat in the vicinity; also, the population viability for any individual migratory bird species was not expected to be in jeopardy as a result of the project.	Mitigation measures included suggesting project activities to occur outside of the migratory bird season. If project activities were to occur during migratory bird season, a qualified biologist would need to conduct bird surveys for nesting species prior to construction. If an active nest was identified during the study, a "no-activity" buffer of 200 feet would be established until the nest becomes inactive.

ancillary construction activities and pipelines.	permit. • Limit/prevent new material being brought into the drill site without specific environmental analysis.		
Water Quality, Discharge, and Use			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• Effects to plant and animal species from briny, salty, corrosive, or scalding geothermal fluids. • Source of water use. • Sump, pipes, and tanks overflowing, leaking, or spilling and the potential contaminants in leaked fluids. • Use of toxic drilling muds.	• Use liners for sumps/pits if shallow groundwater is present. • Use separate pits for geothermal fluids and drill cuttings. • Maintain 2 feet of freeboard to prevent sump overflow. • Reinject geothermal fluids or use storage tanks. • Place impermeable protection under the rig to facilitate clean-up. • Use water-based and non-toxic geothermal drilling fluids.	The Salt Wells Geothermal Drilling Project EA identified several surface-water impacts, including the potential for flooding, the release/runoff of substances used in the construction process, and pipe or storage-tank rupture affecting water quality. In addition, noted groundwater impacts included decreasing the local groundwater aquifer through proposed use of a water well and groundwater-quality impacts if cooling-water evaporation ponds recharge shallow groundwater.	Mitigation measures for surface-water impacts included containment and clean-up standards for spills of substances, a stormwater pollution prevention program as required under the Clean Water Act, and proper maintenance and monitoring of pipes and storage tanks to avoid ruptures. For groundwater impacts, the EA stated that withdrawals would be limited based on county temporary water-use permits to avoid permanent adverse effects on the aquifer and a NPDES permit would require the developer to demonstrate cooling-water discharges would not degrade groundwater quality.
Safety			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• Improper storage of fuels or hazardous materials. • Release of H_2S. • Fires. • Dangers resulting from well blowout and very high-temperature geothermal fluids.	• Add containment around stored fuels and hazardous materials. • Use H_2S monitoring devices. • Place H_2S and fluid-temperature danger signs. • Store fire-safety equipment at the drill site and planning emergency escape/evacuation route. • Ensure adequate well design to control well	The Steamboat Geothermal Wells Project noted a potential safety concern related to fires occurring at the drill site.	The EA listed the following safety measures: • Drill-rig personnel are to control small fires occurring at the drill site using on-site firefighting equipment. • Notify BLM district office immediately of any wildfire. • A shovel, 5 gallons of water, and a fire extinguisher in all vehicles and drill sites. • Catalytic converters on vehicles inspected often and cleaned of all

	and prevent blowout, including the use of a blowout preventer. • Wear protective clothing.		flammable debris. • Cutting and welding should occur in an area mostly free of vegetation. • Comply with BLM fire restrictions or closures. • Permit smoking only in designated areas.
Noise, Light, and Proximity to Population			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• Noise and light impacts for specific species. • Noise related to transporting equipment and personnel to the site, 24-hour drilling, and well testing may impact species or nearby populations.	• Use sound barriers or blankets. • Shield light downward. • Place time and seasonal restrictions on drilling to protect species and nearby populations.	The Coyote Canyon/Dixie Meadows Geothermal Exploration Projects' EA noted several visual impacts, including temporary visual impacts related to the drill rig and use of lights to drill at night. The EA did not include any potential noise impacts.	The EA provided the following mitigation measures: • All drill rigs and well test facility lights would be limited to those required to safely conduct operations. • All drill rig and well test facility lights should be shielded or directed in a manner to focus direct light on the immediate work area. • Remove equipment upon completion of drilling and testing the wells.
Plugging and Abandoning Wells			
Concerns **Concluded from Expert Team**	**Mitigation** **Concluded from Expert Team**	**Example** **Concerns**	**Example** **Mitigation**
• The site stays un-reclaimed for an extended period of time. • Impacts to groundwater quality, such as those caused by liner degradation. • If the developer plans to revisit and continue work, plugging and abandoning a well may cause more environmental impacts than leaving it in place.	• Provide sufficient bonding amount to cover the cost of reclamation. • Ensure conditions of approval aimed at limiting the time period and well safety during that time period.	The Dixie Meadows Geothermal Exploration Project EA identified about 80 acres where the project would impact existing vegetation cover. Beyond the direct impacts of vegetation removal, the EA also noted the potential for cleared areas to become susceptible to the spread of invasive vegetation.	Mitigation measures included salvaging topsoil, which would reduce the effects of soil compaction during reclamation, as well the use of certified weed-free seed mixes during reclamation. The EA noted that implementing reclamation of the project area would occur within two years of project completion.

Acknowledgements
This work was supported by U.S. Department of Interior Bureau of Land Management's Renewable Energy Coordination under contract L16PG00068 with the National Renewable Energy Laboratory. NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes. We wish to thank the following environmental experts on the Geothermal Expert Team: Casey Strickland, U.S. Department of Energy; Dan Munger and Wyndy Rasuenberger, U.S. Department of Interior; Laurie Hietter, Panorama Environmental Inc.; David Batts, EMPSi; Kyle Snyder, Ormat; and Scott Nichols, U.S. Geothermal.

REFERENCES

43 CFR § 3200 et seq.

Beckers, K., and Young, K.R. "Technical Requirements for Geothermal Resource Confirmation." *GRC Transactions*, Vol. 42 (2018).

BLM (Bureau of Land Management Ridgecrest Field Office). "Environmental Assessment/Initial Study/Mitigated Negative Declaration EA-CA-650-2005-086 Deep Rose Geothermal Exploration Project." (2005).

BLM (Bureau of Land Management Carson City District Office). "Final Environmental Assessment DOI-BLM-NV-C010-2011-0516-EA Dixie Meadows Geothermal Exploration Project." (2011).

BLM (Bureau of Land Management Carson City District Office). "Final Environmental Assessment DOI-BLM-C010-2011-0514-EA McCoy II Geothermal Exploration Project." (2011).

BLM (Bureau of Land Management Carson City District Office). "Environmental Assessment EA-NV-030-07-05 Salt Wells Geothermal Drilling." (2007).

BLM (Bureau of Land Management Carson City District Office). "Environmental Assessment DOI-BLM-NV-C010-2009-006-EA Salt Wells Geothermal Exploratory Drilling." (2009).

BLM (Bureau of Land Management Black Rock Field Office). "Environmental Assessment DOI-BLM-NV-W030-2010-0006-EA DOE/EA-1810 San Emidio Geothermal Exploration Project." (2010).

BLM (Bureau of Land Management Prineville and Burns Districts). "Environmental Assessment DOI-BLM-OR-P040-2011-0021-EA DOE/EZ-1925 Midnight Point and Mahogany Geothermal Exploration Projects, Glass Buttes, OR." (2013).

BLM (Bureau of Land Management Fillmore Field Office). "Environmental Assessment DOI-BLM-UT-W020-2010-042-EA Drum Mountains and Whirlwind Valley Geothermal Exploration Projects." (2011).

BLM (Bureau of Land Management Stillwater Field Office). “Final Environmental Assessment DOI-BLM-NV-C010-2012-0029-EA Tungsten Mountain Geothermal Exploration Project.” (2012).

BLM (Bureau of Land Management Winnemucca Field Office). “Finding of No Significant Impacts/Decision Record DOI-BLM-NV-020-07-01-EA-FONSI Jersey Valley Geothermal Exploration Project.” (2007).

BLM (Bureau of Land Management Stillwater Field Office). “Final Environmental Assessment DOI-BLM-NV-C010-2011-0501-EA Patua Geothermal Project Phase II.” (2012).

BLM (Bureau of Land Management Battle Mountain Field Office). “Finding of No Significant Impact and Decision Record NV063-EA06-098-FONSI Reese River Valley Geothermal Exploration Project.” (2006).

BLM (Bureau of Land Management Tonopah Field Office). “Environmental Assessment DOI-BLM-NV-B020-2012-0214-EA DOE/EA-1921 Silver Peak Area Geothermal Exploration Project.” (2012).

BLM (Bureau of Land Management Stillwater Field Office). “Finding of No Significant Impact DOI-BLM-NV-COI0-2010-0008-EA-FONSI Soda Lake Geothermal Exploration Project.” (2010).

BLM (Bureau of Land Management Fillmore Field Office). “Environmental Assessment DOI-BLM-UT-W020-2009-028-EA Drum Mountain Temperature Gradient Exploration Project.” (2010).

BLM (Bureau of Land Management Stillwater Field Office). “Environmental Assessment DOI-BLM-NV-C010-2010-0010-EA Coyote Canyon and Dixie Meadows Geothermal Exploration.” (2010).

BLM (Bureau of Land Management Stillwater Field Office). “Environmental Assessment DOI-BLM-NV-C010-2014-0019-EA Steamboat Geothermal Well(s) 16-32 Project.” (2014).

BLM (Bureau of Land Management Stillwater Field Office). “Finding of No Significant Impacts DOI-BLM-NV-C010-2014-0019-EA-FONSI Steamboat Geothermal Well(s) 16-32 Project.” (2014).

BLM (Bureau of Land Management Humboldt River Field Office). “Environmental Assessment DOI-BLM-NV-W010-2011-0001-EA Leach Hot Springs Geothermal Exploration Project.” (2011).

BLM (Bureau of Land Management Stillwater Field Office). “Finding of No Significant Impact DOI-BLM-NV-COIO-2012-0050-EA-FONSI Wild Rose Geothermal Project.” (2012).

BLM (Bureau of Land Management Carson City District Office). “Environmental Assessment DOI-BLM-NV-C010-2010-0006-EA Gabbs Valley and Dead Horse Wells Geothermal Exploration Projects.” (2009).

BLM (Bureau of Land Management Stillwater Field Office). “Environmental Assessment DOI-BLM-NV-C010-2012-0051-EA Coyote Canyon South Geothermal Exploration.” (2012).

Glassley, W. E. “Geothermal Energy: Renewable Energy and the Environment.” CRC Press, (2014).

The National Environmental Policy Act of 1969, 42 U.S.C. § 4321.

Stober, I., and Bucher, K., "Geothermal Energy: From Theoretical Models to Exploration and Development." Springer-Verlag, Berlin Heidelberg (2013).

Sutley, N., "Memorandum for Heads of Federal Departments and Agencies, Establishing, Applying, and Revising Categorical Exclusions under the National Environmental Policy Act." https://ceq.doe.gov/docs/ceq-regulations-and-guidance/NEPA_CE_Guidance_Nov232010.pdf (2010).

Young, K.R., Witherbee, K., Levine, A., Keller, A., Balu, J., and Bennett, M. "Geothermal Permitting and NEPA Timelines." *GRC Transactions* 38. http://pubs.geothermal-library.org/lib/grc/1033639.pdf (2014).

APPENDIX

NEPA Documents

Deep Rose Geothermal Exploration Project EA - *EA-CA-650-2005-086*

Dixie Meadows Geothermal Exploration Project EA - *DOI-BLM-NV-C010-2011-0516-EA*

McCoy II Geothermal Exploration Project EA - *DOI-BLM-NV-C010-2011-0514-EA*

Salt Wells Geothermal Drilling EA - *EA-NV-030-07-05*

Salt Wells Geothermal Exploratory Drilling Program EA - *DOI-BLM-NV-C010-2009-006-EA*

San Emidio Geothermal Exploration Project EA - *DOI-BLM-NV-W030-2010-0006-EA*

Midnight Point and Mahogany Geothermal Exploration Projects, Glass Buttes Exploration EA - *DOI-BLM-OR-P040-2011-0021-EA*

Drum Mountains and Whirlwind Valley Geothermal Exploration Projects EA - *DOI-BLM-UT-W020-2010-042-EA*

Tungsten Mountain Geothermal Exploration Project EA - *DOI-BLM-NV-C010-2012-0029-EA*

Jersey Valley Geothermal Exploration Project FONSI - *DOI-BLM-NV-020-07-01-EA-FONSI*

Patua Geothermal Project Phase II EA - *DOI-BLM-NV-C010-2011-0501-EA*

Reese River Valley Geothermal Exploration Project FONSI - *NV063-EA06-098-FONSI*

Silver Peak Silver Peak Area Geothermal Exploration Project EA - *DOI-BLM-NV-B020-2012-0214-EA*

Soda Lake Geothermal Exploration Project FONSI - *DOI-BLM-NV-C010-2010-008-EA-FONSI*

Drum Mountain Temperature Gradient Exploration Project EA - *DOI-BLM-UT-W020-2009-028-EA*

Coyote Canyon and Dixie Meadows Geothermal Exploration EA - *DOI-BLM-NV-C010-2010-0010-EA*

Steamboat Geothermal Well(s) 16-32 Project EA and FONSI - *DOI-BLM-NV-C010-2014-0019-EA*

Leach Hot Springs Geothermal Exploration Project EA - *DOI-BLM-NV-W010-2011-0001-EA*
Wild Rose Geothermal Project FONSI - *DOI-BLM-NV-C010-2012-0050-EA-FONSI*
Gabbs Valley and Dead Horse Wells Geothermal Exploration EA - *NV-C010-2010-006-EA*
Coyote Canyon South Geothermal Exploration EA - *DOI-BLM-NV-C010-0051-EA*