December 22, 2020

MOUNT SPURR NONCOMPETITIVE GEOTHERMAL PROSPECTING PERMIT

Preliminary Written Finding of the Director

Alaska Department of
NATURAL RESOURCES
DIVISION OF OIL & GAS

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Prepared by:
Alaska Department of Natural Resources
Division of Oil and Gas

December 22, 2020

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Chapter One: Director's Preliminary Written Finding and Decision

This preliminary finding is the director of the Alaska Department of Natural Resources (DNR) Division of Oil and Gas' (DO&G) decision under AS 38.05.181 that the state's best interests would be served by issuing the Mount Spurr Noncompetitive Geothermal Prospecting Permit (Prospecting Permit or Prospecting Permit Area) as described in this preliminary written finding to Raser Power Systems, LLC. The Prospecting Permit Area is located on the southern flank of Mount Spurr. The Prospecting Permit Area is approximately 6,750 acres in 3 tracts located northwest of Trading Bay and approximately 40 miles west of Tyonek and is assigned Alaska Division of Lands (ADL) number 393958. Any disposal of geothermal resources must be preceded by a determination under AS 38.05.035(e) that the disposal is in the best interest of the state (11 AAC 84.700(b)). The director of DO&G reviewed all facts and issues known or made known to them, and limited the scope of the administrative review and finding to the reasonably foreseeable significant effects of the uses proposed to be authorized by the disposal (AS 41.06.005; AS 38.05.035(e)(1)(A); AS 38.05.181; 11 AAC 84.700-.790).

After weighing the facts and issues known at this time, considering applicable laws and regulations, and balancing the potential positive and negative effects given the mitigation measures and other regulatory protections, the director preliminarily finds that the potential benefits of issuing a noncompetitive geothermal prospecting permit outweigh the possible negative effects, and that the Mount Spurr Noncompetitive Geothermal Prospecting Permit is in the best interest of the State of Alaska.

A. Description of the Proposed Prospecting Permit Area

On February 20, 2019, DO&G published a Call for Applications. The area included in the Call for Applications consisted of 12 tracts comprising approximately 28,800 acres on the southern flank of Mt. Spurr. The proposed geothermal exploration solicitation area was located within T. 13 & 14 N., R. 16 & 17 W., Seward Meridian. The state owns the land within the solicitation area. At the conclusion of the Call for Applications, the commissioner determined the tracts within the area would be disposed of by a noncompetitive prospecting permit (11 AAC 84.720(a)).

The Prospecting Permit Area falls entirely within the Kenai Peninsula Borough. Mount Spurr is remote and uninhabited. The closest cities, towns, villages, and communities to the area are Tyonek and Beluga on the west coast of Cook Inlet, and Nikiski on the east coast of Cook Inlet. Many of the industries and businesses of the area are supported directly or indirectly by natural resources. Industries include oil and gas, coal and timber, commercial fishing, and government. Cultural and historic resources or archaeological sites are not known to be present in the Prospecting Permit Area.

The Prospecting Permit Area is mainly characterized by the maritime climate zone. The major watersheds near the area include the Chakachatna and McArthur rivers. All surface waters in the Prospecting Permit Area drain into Cook Inlet.

Mount Spurr is an active snow- and ice-covered stratovolcano located on the west side of Cook Inlet. Geologic hazards exist in the Mount Spurr area, including volcanic ash clouds, ash fallout and volcanic bombs, pyroclastic flows, debris avalanches, tsunamis, earthquakes, directed blasts, lahars and floods, volcanic gases, and lava flow.

B. Director's Preliminary Finding

State laws AS 38.05.035(e), AS 38.05.181, and 11 AAC 84.700(b) require that before approving a noncompetitive geothermal prospecting permit, the director must determine whether the disposal is in the best interest of the state. After an appropriate review, the director preliminarily determined that approving the Mount Spurr Noncompetitive Geothermal Prospecting Permit is in the best interest of the state.

A noncompetitive prospecting permit will allow Raser Power Systems, LLC the exclusive right, for a period of two years, to prospect for geothermal resources on state land included under the permit. The commissioner has discretion to renew the permit for an additional one-year term if the permittee has been unable, despite reasonable diligence, to show a discovery of geothermal resources in commercial quantities (AS 38.05.181(c), 11 AAC 84.730(b)). A holder of a prospecting permit has the right, upon showing of a discovery of geothermal resources in commercial quantities and the submission of a development plan acceptable to the commissioner, to convert the noncompetitive prospecting permit to a noncompetitive lease (AS 38.05.181(c)).

In making this determination, AS 38.05.035(e)(1)(A) requires that the director issue a written finding establishing the scope of the administrative review on which the director's determination is based and the scope of the written finding supporting that determination.

The scope of the administrative review and finding may address only reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal (AS 38.05.035(e)(1)(A)). The scope of the administrative review and finding may be limited to the disposal phase (AS 38.05.035(e)(1)(B)). Additionally, the director may not be required to speculate about possible future effects of the disposal (AS 38.05.035(h)). A discussion of phasing is included in Chapter Two. A discussion of potential cumulative effects from this disposal and subsequent geothermal exploration, development, and production is included in Chapter Eight.

In making this preliminary finding, the director considered the Prospecting Permit Area, including its terrestrial and freshwater habitats, and the fish, birds and wildlife that use them; current uses of the area; its geothermal resource potential; reasonably foreseeable, significant effects of geothermal activities; and the mitigation measures for protection of the area's resources, habitats, and uses.

The director limited the scope of this finding to an administrative review of the noncompetitive geothermal prospecting permit, as well as applicable statutes and regulations and the facts about the land that are known to him and are material to their decision. The director also considered the reasonably foreseeable significant effects of a disposal of interest in state land.

The type, location, duration, timing, or level of any exploration or development activities that may subsequently occur cannot be precisely determined. Therefore, the director did not speculate the possible specific effects of future exploration, development, and production activities resulting from the disposal.

The effects of future exploration, development, and production are considered at each subsequent stage, when government agencies and the public review permit applications for the specific activities proposed at specific locations in the area. However, the director did consider, in general terms, the potential effects that may occur subsequent to prospect permitting and, in the event that geothermal resources are discovered in commercial quantities, leasing.

Although the initial benefit to the state is the primary effect of exploration, the director recognizes that geothermal exploration, development, and production subsequent to granting the Prospecting Permit may result in impacts to and around the Prospecting Permit Area and its current uses. Therefore, general mitigation measures are included to avoid, minimize, and mitigate potential negative effects. They address facilities and operations, reduction of impacts to habitats, fish and wildlife, harvest activities, management of fuels, hazardous substances, wastes, access, historical and cultural resources, and local hire.

The permittee must comply with all applicable local, state, and federal codes, statutes, and regulations. Future authorizations may require additional project-specific and site-specific mitigation measures.

The state has sufficient authority through general constitutional, statutory, and regulatory authority, the terms of the disposal, and plans of exploration, operations and development, to ensure that permittees/lessees conduct their activities safely and in a manner that protects the integrity of the environment and maintains opportunities for other natural resource uses such as fishing or subsistence and other concurrent uses. This written finding considers the potential that the prospecting permit could be converted to leases if the conditions outlined in 11 AAC 84.740 are met. Mitigation measures included in Chapter Nine would be carried forward on any subsequent lease or leases.

After weighing the facts and issues known to the director at this time, considering applicable laws and regulations, and balancing the potential positive and negative effects given the proposed mitigation measures and other protections, the director preliminarily concludes that the potential benefits of the Prospecting Permit outweigh the possible negative effects, and that the approval for the Mount Spurr Noncompetitive Geothermal Prospecting Permit will best serve the interests of the State of Alaska.

This preliminary finding is subject to revision based on comments received by DO&G during the period set out for receipt of public comment, as provided in AS 38.05.035(e)(5)(A). Members of the public are encouraged to comment on any part of this preliminary finding. In commenting, please be as specific as possible.

Comments must be in writing and received by 5:00 pm on January 23, 2021 in order to be considered and must be sent to Best Interest Findings:

By mail: Alaska Department of Natural Resources
Division of Oil and Gas
550 W 7th Ave, Suite 1100
Anchorage AK 99501-3560
By fax: 907-269-8938
By email: dog.bif@alaska.gov

The DO&G complies with Title II of the Americans with Disabilities Act of 1990. This publication will be made available in alternate communication formats upon request. Please contact the Best Interest Findings Group at (907) 269-8800 or dog.bif@alaska.gov. Requests for assistance must be received at least 96 hours prior to the comment deadline to ensure necessary accommodations can be provided.

Following review of comments on this preliminary written finding and any additional relevant information, the director will make a final determination whether disposal of geothermal resources in the Mount Spurr Prospecting Permit Area is in the best interest of the state and will issue a final finding and decision. To be eligible to file an appeal of the final finding to the DNR commissioner, a person must provide written comments during the comment period of this preliminary finding set out in the previous paragraph. Additional information regarding the public comment process and requests for reconsideration and appeals can be found in Chapter Two. A copy of the final decision can be sent to any person commenting on the preliminary decision and will include an explanation of the appeal process.

DocuSigned by:

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Tom Stokes

Director, Division of Oil and Gas

Chapter Two: Authority and Scope of Review

The Alaska Constitution provides that the state's policy is "to encourage . . . the development of its resources by making them available for maximum use consistent with the public interest" and that the "legislature shall provide for the utilization, development, and conservation of all natural resources belonging to the State . . . for the maximum benefit of its people" (Alaska Constitution, Article VIII, §1 and 2). To comply with this provision, the legislature enacted Title 38 of the Alaska Statutes (AS 38) and directed the DNR to implement the statutes.

The state may develop geothermal resources under the statutory guidance of AS 38.05.181. The procedures for disposal of geothermal resources are set out in regulations 11 AAC 84.700-790. Other agencies also have jurisdiction for activities resulting from resources exploration, development, and production.

A. Background

Disposal of the Mount Spurr area has been approved in the past for geothermal exploration. DNR held its first geothermal lease sale in the Mount Spurr area on May 17, 1983. 10,240 acres in 16 tracts were offered in Competitive Geothermal Lease Sale 1. One tract (Tract No. 9) received a bid. The lease for that tract was terminated in 1992.

On June 24, 1986, DNR offered 2,640 acres in two tracts in the Mount Spurr area for geothermal exploration and development in Competitive Geothermal Lease Sale 2. Both tracts received bids. The lease for Tract 1 expired in 1996, and the lease for Tract 2 was terminated in 1990. State resource evaluation officials indicate that one possible reason geothermal resources were never developed was the collapse of oil and gas prices in the mid-1980s, which made geothermal projects less attractive.

A third geothermal lease sale was conducted on September 10, 2008. A Best Interest Finding was issued on June 16, 2008 authorizing the sale. This most recent lease sale encompassed 36,057 acres in 16 tracts ranging from 250 to 2,560 acres. All 16 tracts received bids from a total of three parties. Ormat Nevada, Inc. (Ormat) performed some exploration work on the 15 leases that they won in the lease sale. Additional information from their exploration work is included in the Geology and Geophysics section of this Finding. One of the leases was procured by an individual. The remaining 15 leases that Ormat won were relinquished on dates ranging from October 7, 2013 through October 3, 2016.

Geothermal resources are reservoirs of hot water that exist at varying temperatures and depths below the Earth's surface. Geothermal hot water and steam can reach the earth's surface in the form of hot springs, fumaroles, geysers, mud pots, or steam vents. Geothermal wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications, including electricity generation, heating and cooling and the heat energy can

be used for generating electricity or for direct uses such as heating buildings, greenhouses, industrial processes (USDOE 2020; BLM 2020). To be extractable, geothermal resources must be trapped in reservoirs near the surface of the earth.

Geothermal features can be observed in areas of active or inactive volcanoes. Subsurface magma heats groundwater, creating steam and hot water. The resulting hot, less dense water rises through faults, fissures, and cracks in the ground. On the surface, hot springs, geysers, fumaroles, and mud pits are created. Hot springs in active volcanic zones may produce superheated water. In non-volcanic areas, the temperature of rocks within the Earth also increases with depth. This temperature increase is known as the Geothermal Gradient. Fumaroles are geothermal features resulting from interactions of released volcanic gases and the groundwater system. These occur in areas where a magma conduit passes through the water table and heat from the magma causes water to become steam (NPS 2020).

Hot springs and fumaroles are indicative of near-surface geothermal resources. Recently active volcanoes are also indicative of geothermal sites. Alaska's approximately 140 volcanoes (one-third of which are active) and more than 90 hot springs provide tremendous potential for geothermal energy development, except that the vast majority of these sites are located far from population centers (DGGS 1983). However, the site of the Mount Spurr Noncompetitive Geothermal Prospecting Permit Area is in relatively close proximity to the Southcentral Alaska power grid that makes this project area potentially viable as a geothermal energy production site.

Construction of geothermal power plants is capital intensive. On the other hand, like other renewable energy sources, geothermal plants have few additional long-term costs in comparison to fuel-based electric power plants. They bear no fuel costs or associated transportation costs, and operation and maintenance costs are relatively minor. Despite the high capital costs, a typical geothermal plant's lifetime operating costs are much less than that of a diesel-powered facility of equivalent capacity. (Yanity and Kolker 2006).

A. Process

Alaska statutes govern the disposal of state-owned subsurface interests. Under AS 38.05.035(e), the DNR director may not dispose of state land, resources, property, or interests unless the director, with the consent of the commissioner, first determines in a written finding that such action will serve the best interests of the state.

DO&G initiated the process for this Prospecting Permit at Mount Spurr by issuing a Nomination of Lands on August 15, 2018. DO&G was seeking nominations of lands with geothermal resources for potential future disposal. The program was introduced as a way to identify proposed geothermal disposal areas for potential geothermal lease sales or prospecting permits. On November 13, 2018, Cyrq Energy responded to the Nomination of Lands expressing interest in the Mount Spurr area in the same area where the 2008 lease sale was conducted. Mount Spurr was the only area nominated for geothermal exploration in response to the August 15, 2018 request.

On February 20, 2019, DO&G published a Call for Applications for a period of 30 days. The area included in the Call for Applications consisted of 12 tracts comprising approximately 28,800 acres, northwest of Trading Bay and approximately 40 miles west of Tyonek on the southern flank of Mt.

Spurr. The proposed geothermal exploration solicitation area was located within T. 13 & 14 N., R. 16 & 17 W., Seward Meridian. One application was received in response to the Call for Applications and no public comments were submitted, therefore this Prospecting Permit is being offered as a non-competitive Prospecting Permit for a period of 2 years at a rental rate of $3/acre. The Prospecting Permit can be renewed for an additional year if the permittee has been unable to show a discovery of geothermal resources in commercial quantities despite showing reasonable diligence as defined in 11 AAC 84.730(b).

B. Scope of Administrative Review

In the written finding, the director establishes the scope of the administrative review on which the director's finding is based. As required by AS 38.05.035(e)(1)(A)–(C), the director, in the written finding:

- shall establish the scope of the administrative review on which the director's determination is based, the scope of the written finding supporting that determination, and the scope of the administrative review and finding may only address reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal;

- may limit the scope of an administrative review and finding for a proposed disposal to a review of (1) applicable statutes and regulations, (2) facts pertaining to the land, resources or property, or interest in them that are material to the determination and known to the director or knowledge of which is made available to the director during the administrative review, and (3) issues that, based on the applicable statutes, regulations, facts, and the nature of the uses sought to be authorized by the disposal, the director finds are material to the determination of whether the proposed disposal will serve the best interests of the state; and

- may, if the project for which the proposed disposal is sought is a multi-phased development, limit the scope of an administrative review and finding for the proposed disposal to the applicable statutes, and regulations, facts and issues that pertain solely to the disposal phase of a project when the conditions of AS 38.05.035(e)(1)(C)(i)–(iv) are met.

It must include the scope of the written finding that supports that determination. The scope of the administrative review and finding may address only reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal (AS 38.05.035(e)(1)(A)). The director does not speculate about possible future effects (AS 38.05.035(h)).

For an effect to be "reasonably foreseeable", there must be (1) some cause/result connection between the proposed disposal and the effect to be evaluated; (2) a reasonable probability that the effect will occur as a result of the disposal; and (3) the effect will occur within a predictable time after the disposal. Therefore, this finding does not speculate about future effects, but instead reviews only reasonably foreseeable effects of the proposed disposal. A reasonably foreseeable effect must also be "significant." Significant means a known and noticeable impact on or within a reasonable proximity to the area involved in the disposal.

Further, the director may limit the scope of an administrative review and finding for a proposed disposal to:

- applicable statutes and regulations;
- the facts pertaining to the land, resources, or property, or interest in them, that the director finds are material to the determination and that are known to the director or knowledge of which is made available to the director during the administrative review; and
- issues that, based on the statutes and regulations, on the facts as described, and on the nature of the uses sought to be authorized by the disposal, the director finds are material to the determination of whether the proposed disposal will best serve the interests of the state (AS 38.05.035(e)(1)(B)).

Therefore, the scope of review in this finding addresses the reasonably foreseeable, significant effects of the uses to be authorized by the proposed disposal and is limited to the applicable statutes and regulations, the material facts and issues known to the director that pertain to the proposed noncompetitive geothermal prospecting permit disposal phase, and issues that the director finds are material to the determination of whether the proposed disposal will best serve the interests of the state. AS 38.05.035(e)(1)(C) authorizes the commissioner to limit this finding to evaluate the disposal phase.

In a preliminary or final written finding, the director must consider and discuss facts related to topics set out under AS 38.05.035(g)(1)(B)(i)–(xi) that are known at the time the finding is being prepared. The director must also consider public comments during the public comment period and within the scope of review. The scope of the administrative review is confined to the impacts on the Prospecting Permit Area which is approximately 6,750 acres in 3 tracts located northwest of Trading Bay along the southern flanks of Mount Spurr and the surrounding environments. Figure 1 in Chapter Three depicts the location of the Prospecting Permit Area.

C. Review by Phase

The director may limit the scope of an administrative review and finding for a proposed disposal to evaluate the potential effects of the proposed disposal when the director has sufficient information and data available upon which to make a reasoned decision.

Under AS 38.05.035(e)(1)(C), if the project for which the proposed disposal is sought is a multi-phased development, the director may limit the scope of an administrative review and finding for the proposed disposal to the applicable statutes and regulations, facts, and issues identified above pertaining solely to the disposal phase of the project under the following conditions:

(i) the only uses to be authorized by the disposal are part of that phase;

(ii) the disposal grants the permittee the exclusive right to prospect for geothermal resources on state land included under the permit, and, before the next phase of the project may proceed, public notice and the opportunity to comment are provided under regulations adopted by the department;

(iii) the department's approval is required before the next phase may proceed; and

(iv) the department describes its reasons for a decision to phase.

Here, the director has met condition (i) because the only uses authorized are part of the disposal phase. The disposal phase is the prospecting permit phase of this project. As defined in Kachemak Bay Conservation Society v. State, Department of Natural Resources, "disposal" is a catch all term for all alienations of state land and interests in state land.[1] In Northern Alaska Environmental Center v. State, Department of Natural Resources, the court further held that a disposal was a conveyance of a property right.[2] For a geothermal development project, the lease or prospecting permit is the only conveyance of property rights DNR approves. The prospecting permit or lease gives the permittee or lessee, subject to the provisions of the permit or lease and applicable law the exclusive right to drill for, extract, remove, and process geothermal resources, as well as the nonexclusive right to conduct within the permitted or leased area geological and geophysical exploration for geothermal resources, the nonexclusive right to install pipelines and build structures on the Prospecting Permit Area or lease to find, produce, save, store, take care of, and market all geothermal resources, and to house and board employees in its operations on the Prospecting Permit Area or lease area. While the permittee or lessee has these property rights upon entering into the prospecting permit or lease, the prospecting permit or lease itself does not authorize any geothermal exploration activities on the prospecting permitted or leased tracts without further permits from DNR and other agencies. There are no additional property rights to be conveyed at later phases.

Condition (ii) is met, first, because this Prospecting Permit is for the disposal of available land or an interest in land, for geothermal resources. Second, condition (ii) is met because public notice and opportunity to comment are provided for each phase of a project. Public notice and the opportunity to comment on the disposal phase of a prospecting permit is provided through the preliminary best interest finding under AS 38.05.035(e), AS 38.05.945, and 11 AAC 84.720(c). Subsequent post-disposal phases may not proceed unless public notice and the opportunity to comment are provided under regulations adopted by DNR. DNR provides public notice and opportunity to comment for plans of operation that initiate a new phase under 11 AAC 84 as authorized by AS 38.05.

Condition (iii) is met because DNR's approval is required before the next phase may proceed.

Condition (iv) is met by the findings in Chapter One discussing the speculative nature of current information on what future development projects and methods may be proposed that would require post-disposal authorizations; and what permit conditions and mitigation requirements will be appropriate for authorizations at later phases.

This preliminary best interest finding satisfies the requirements for phased review under AS 38.05.035(e)(1)(C).

D. Appeal

A person affected by this decision may appeal it in accordance with 11 AAC 02. Any appeal must be received within 20 calendar days after the date of "issuance" of this decision, as defined in 11 AAC 02.040(c) and (d) and may be mailed or delivered to the Commissioner, Department of Natural Resources, 550 W. 7th Avenue, Suite 1400, Anchorage, Alaska 99501; faxed to 1-(907) 269-8918, or sent by electronic mail to dnr.appeals@alaska.gov. Under 11 AAC 02.030, appeals and requests for reconsideration filed under 11 AAC 02 must be accompanied by the fee established in 11 AAC 05.160(d)(1)(F), which has been set at $200 under the provisions of 11 AAC 05.160 (a) and (b).

If no appeal is filed by the appeal deadline, this decision becomes a final administrative order and decision of the department on the 31st calendar day after issuance. An eligible person must first appeal this decision in accordance with 11 AAC 02 before appealing this decision to the Superior Court. A copy of 11 AAC 02 may be obtained from any regional information office of the Department of Natural Resources.

E. References

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USDOE (United States Department of Energy Office of Energy Efficiency and Renewable Energy). 2020. Geothermal Basics. https://www.energy.gov/eere/geothermal/geothermal-basics (Accessed 3/19/2020).

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Chapter Three: Description of the Disposal Area

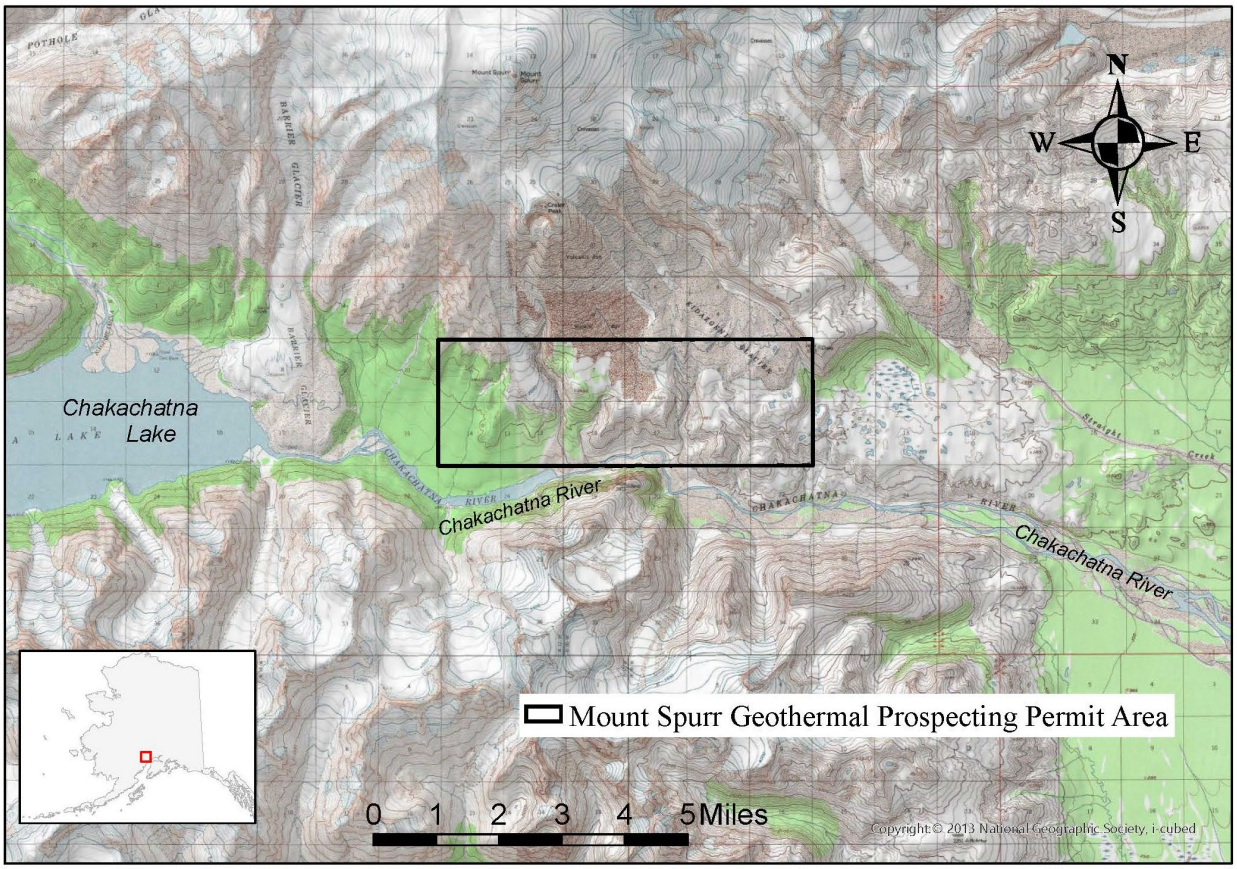
A. Property Description

Mount Spurr is located approximately 80 miles from Anchorage on the west side of Cook Inlet. It has an elevation of 11,070 feet and is one of the northernmost peaks in the Aleutian Island-Alaska Peninsula volcanic arc. Much of the Prospecting Permit Area was recently glaciated, and the lower elevations are usually gently sloping with thickets of alder. The state owns the land within the Prospecting Permit Area. The Bureau of Land Management and Cook Inlet Region Inc. own the remainder of land in the vicinity of the Prospecting Permit Area.

The boundaries of the Prospecting Permit Area are depicted in **Figure 1**, Mount Spurr Geothermal Prospecting Permit Area. The area is located northwest of Trading Bay, along the southern flank of Mount Spurr. It is located to the east of Chakachamna Lake, which is adjacent to Lake Clark National Park and Preserve and includes a short section of the Chakachatna River. The Prospecting Permit Area, which is approximately 40 miles west of the village of Tyonek, lies entirely within the Kenai Peninsula Borough. The Prospecting Permit Area contains approximately 6,750 acres divided into 3 tracts, each consisting of approximately 2,560 acres.

Included in the state-owned land is Power Site Classification (PSC) No. 395 (subject to Section 24 of the Federal Power Act of 1920), and the bed of the Chakachatna River. This would be the site of the Chakachamna Hydroelectric Project, an application for which was filed with the Federal Energy Regulatory Commission on November 3, 2009. Under Section 24 of the Federal Power Act, the federal government may enter upon, occupy, and use any part of the state lands within the former classification for waterpower sites, waterpower development, or electrical transmission. The Chakachamna Hydroelectric Project would be located at the existing Chakachamna Lake on the Chakachatna River. The proposed project would consist of a 9-foot-high, 200-foot-long concrete flow-control weir at the Chakachamna Lake outlet, a spillway, and a powerhouse containing four generating units with a total installed capacity of 300 megawatts. Two 230-kilovolt transmission lines, each approximately 42 miles long, would connect to existing power lines. This is no longer an active permit as the application has expired (FERC 2010).

Figure 1, Mount Spurr Geothermal Prospecting Permit Area.



B. Cultural and Historical Background and Resources

At the time of first European contact, the Dena'ina people occupied the Cook Inlet area. These nomadic bands came to the region about A.D. 500 to 1,000 (CIRI 2020). Tyonek is a coastal Dena'ina Athabascan community of 168 people located approximately 40 miles east of Mount Spurr and is the nearest settlement to the Prospecting Permit Area. Their local federally recognized tribal organization is the Native Village of Tyonek. The population consists of over 80 percent Alaska Natives (DCCED 2020). The people of Tyonek speak an Athabascan dialect called Dena'ina. The people of and from Tyonek have a culture rich in subsistence of hunting, trapping, fishing, and whaling; song and dance; storytelling; and religion. The word "Tebughna," which translates as "the Beach People," is the name for the people of Tyonek (Tyonek Native Corporation 2020; DCCED 2020).

C. Geologic Hazards

Mount Spurr is an active volcano. Almost all of the eruptions in the past several thousand years emanated from Crater Peak, a vent located on the south flank of the volcano. Mount Spurr is classified as a Very High Threat volcano in the National Volcanic Threat Assessment. A single explosive eruption produced significant ash fall in the Anchorage area in 1953. Mount Spurr is the highest in elevation, and

easternmost historically active volcano in the Aleutian arc. It is a Quaternary stratovolcano located near the northeastern end of the Aleutian volcanic arc. The arc appears to define a large, dissected stratovolcano (Miller et al. 1998; Schaefer 2020). Portions of the Prospecting Permit Area were heavily blanketed with ash in the 1953 eruption. Also, during that eruption, a slurry of mud, sand, gravel and boulders descended the south flank of Crater Peak and dammed the Chakachatna River. That dam is still in place, and is the reason why the river upstream, south of Tract 8 is wider than the river downstream. It is not uncommon for such dams to impound large amounts of water which are subsequently released as floods when the dams fail. There is geologic evidence that similar, but larger dams have formed and failed in the past. Volcanologists at the Division of Geological and Geophysical Surveys consider the floodplain of the Chakachatna River to be at risk of similar floods following future eruptions (Schaefer 2020; Waythomas and Nye 2002).

In 1992, three explosive eruptions occurred separated by 4-7 weeks. These eruptions produced substantial ash fall up to 400 miles downwind of the volcano source and drifting ash clouds that disrupted air traffic. In the Prospecting Permit Area these eruptions produced pyroclastic flows and lahars on the southern flanks of Crater Peak; a zone of impact of ballistic blocks (each tens of centimeters in diameter) which covered much of the area in Tract 3; and thick local ashfall (Keith 1995; Schaefer 2020).

Increased seismic activity and heat flux were observed at the summit of Mount Spurr in 2004 and 2006, which was a shift from the most recent and more common eruptive events from Crater Peak. This activity resulted in the melting of a large volume of ice and the formation of the first observed crater lake at the summit of Mount Spurr. During this event, significant volumes of magmatic gasses were emitted. This seismic activity did not escalate into an eruption. However, the melting snow and ice caused muddy debris flows that extended down to the 8600’ level on the east and northeast flanks of the volcano. Significant seismic unrest continues. The Alaska Volcano Observatory (AVO) considers eruptions from Crater Peak or Mount Spurr summit to be a virtual certainty in the future (Smithsonian Institution 2013; Schaefer 2020).

The current and anticipated level of volcanic activity is not expected to create conditions under which geothermal prospecting would be unduly hazardous. If prospecting were to be undertaken over a period of days or weeks, AVO has expressed a willingness to set up communications protocols with prospectors to keep them appraised of any significant changes in the status of the volcano. If a geothermal resource were to be discovered, then hazards from future eruptions should be considered before the development of infrastructure for the exploitation of that resource (Schaefer 2020).

1. Volcanic Hazards

Volcanic hazards include volcanic-ash clouds, volcanic-ash fallout and falling rock debris, lava flows, and lahars. Tephra is a term used to describe all of the fragments of rock and debris that are sent into the air from an erupting volcano. Most of the material falls back onto the slopes of the volcano itself, but the smallest particles and ash can be carried for over a thousand miles. Low concentrations of falling ash can disrupt human activities hundreds of miles downwind, and drifting clouds of fine ash can impact jet aircraft travel. Volcanic ash is abrasive, melts when it encounters temperatures associated with running jet engines, and can cause engine failure (AVO 2017; USGS 2018).

Lahars are formed when hot volcanic debris interacts with snow and ice to form fast-moving slurries of water, mud, rocks, and sand. Lahars, which typically follow streams and drainages, are expected to form

during most future eruptions of Crater Peak and would be a hazard to people and facilities in the Chakachatna River valley (AVO 2017). A pyroclastic flow is a fast-moving mixture of volcanic rock, debris, and gas that flows downslope during eruptive events. Pyroclastic flows may result from explosive eruptions or the collapse of the lava dome; as the lava dome cools, it may collapse and fall back toward the volcano moving debris downslope several miles beyond the vent (Waythomas and Waitt 1998; USGS 2020a). Pyroclastic flows typically travel along valleys and low-lying topography, but remain a significant hazard to people or facilities within close proximity to the volcano (Smithsonian Institution 2020).

Less likely hazards include debris avalanching where rapidly moving mass of rocks, initiated by a large-scale failure on the side or edge of the volcano, travels rapidly downhill. A large prehistoric debris avalanche occurred at Mount Spurr and extended approximately 20 kilometers beyond the base of the volcano and blocked the Chakachatna River. The change of river course is still noticeable as the river is much wider upstream of the former dam. Slope failure or landslides initiated by an eruption on the flanks of a volcano remain a potential threat in the Mount Spurr vicinity (Waythomas and Nye 2002).

Volcanic gas venting can build to toxic levels in the absence of wind and migrate downhill, accumulating in valleys or along low points. Although unlikely, volcanic gases could pose a threat to people working in valleys or low points below the volcano. Gases are emitted by the majority of active volcanoes, most commonly in the form of water vapor, carbon dioxide, carbon monoxide, sulfur dioxide, and hydrogen sulfide. These gasses are emitted because magma contains dissolved gases and boils off shallow ground water that is typically present within volcanoes. Finally, the potential for lava flows to travel a few kilometers from the Crater Peak vent remains a possible threat to any facilities or people in the area (Waythomas and Nye 2002).

2. Landslides

Landslides are common on volcanic cones and the surrounding areas because they are typically tall, steep, and weakened by the rise and eruption of molten rock. Magma releases volcanic gases that can partially dissolve in groundwater. The released gasses can result in a hot acidic hydrothermal system that weakens rock formations. The layers of lava and loose fragmented rock debris can lead to fault zones that move frequently. Landslides can cross valley divides and run up slopes several hundred meters high. Geothermal resources are often located under steep terrain, and development requires substantial excavation to prepare facility sites. As a result of extensive excavation, erosion and landslides could occur. Slopes underlain by weak bedrock can be a serious engineering problem (USGS 2020b). On May 2, 2005, a small debris flow was captured on a webcam with views of the summit of Mount Spurr. A week later, observations revealed that fumaroles were exposed on the north shore of the lake and the cauldron lake level had dropped by approximately 15 meters (Smithsonian Institution 2013).

The central and eastern portions of the Prospecting Permit Area contain steep slopes. Some slopes are composed of volcanic ash and could be unstable. Design and construction of all drill pads built in the Prospecting Permit Area must be approved through the plans of operations process by DO&G, and sound engineering practices will be required to prevent poor siting of facilities. Mitigation measures prohibit the siting of facilities in environmentally sensitive areas. A discussion of mitigation measures is included in Chapter Nine.

3. Subsidence

In hydrothermal fields, land subsidence is a potential effect of development. Although land subsidence may occur due to the withdrawal of geothermal fluids, it is not because the reservoirs are commonly over-pressured. If all the geothermal fluids are not injected back into the geothermal reservoir, subsidence may occur because of a drop-in reservoir pressure and changes in the pore space in the rock. At the Wairakei geothermal field in New Zealand, 15 meters of subsidence in the land was observed as a result of 50 years of geothermal fluid extraction, which is one of the most prominent examples of man-made subsidence in the world (Keiding et al. 2010).

Whether geothermal development at Mount Spurr would cause subsidence is unknown. If hydrothermal resources are discovered at Mount Spurr, lessees will be required by Mitigation Measure 1.l. to conduct a second order survey of the land surface before and during production to determine whether subsidence has occurred. If production results in subsidence, and if subsidence is hazardous to production operations or adjoining land uses, the lessee will be required, as necessary, to adjust production and injection rates or to suspend operations.

4. Induced Seismicity

Geothermal fields are typically located in seismically active areas or along active faults. Because geothermal resource extraction redistributes fluid pressure in the reservoir, earthquakes could be triggered. Geothermal fields in tectonically active regions often showed seismicity, but not always of large magnitude (Buijze et al. 2019).

Mount Spurr is in an active seismic area, and seismic effects are possible. Increased seismicity could be hazardous to production operations and adjoining land uses. Therefore, the state may install seismographs or other instruments in producing fields to detect induced seismic activity. If geothermal production induces seismicity, and if induced seismicity could be hazardous, the permittee will be required, as necessary, to adjust production and injection rates or to suspend operations under Mitigation Measure 1.m.

D. Mitigation Measures

Several geologic hazards exist in the Prospecting Permit Area that could pose potential risks to geothermal exploration, development, or transportation. As discussed above, the potential hazards include volcanic ash clouds, pyroclastic flows, debris avalanches, landslides and subsidence, induced seismicity, lahars and floods, volcanic gases, and lava flow. Geothermal resource infrastructure does not currently exist in the Cook Inlet area.

Measures in this preliminary finding, along with laws imposed by the state, federal, and local agencies, in addition to design and construction standards discussed above, are expected to minimize or mitigate some potential hazards. However, geothermal resource exploration, development, production, and transportation on an active volcano have risks associated with them. There is no known natural protection from geohazards. A complete list of mitigation measures is found in Chapter Nine.

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Chapter Four: Habitat, Fish, and Wildlife

This chapter considers and discusses the habitats and fish and wildlife populations of the Prospecting Permit Area. The intent is to focus on habitats and fish and wildlife of the area that have important subsistence, recreational, or commercial value and that are material to the determination if the disposal will best serve the interests of the state. Uses of fish and wildlife are discussed further in Chapter Five, and potential cumulative impacts to fish and wildlife from geothermal exploration and development is discussed in Chapter Eight. The director finds that facts pertaining to the land resources, or property, or interests in them are material to this determination. The Mount Spurr Prospecting Permit Area contains habitats that support several fish and wildlife species.

A. Major Habitats of the Disposal Area

1. Terrestrial Habitats

The Prospecting Permit Area is comprised of approximately 95 percent uplands which is predominantly forested with some bare ground and shrub ground coverage. The remaining 5 percent of the Prospecting Permit Area is wetland (Boggs et al. 2019), but that may be underestimated because of the survey methodology. The Prospecting Permit area is in a transitional zone between the marine west coast forest and boreal cordillera ecoregions of North America (EPA 2006).

The region of the Prospecting Permit Area contains mixed forests of white (*Picea glauca*) and Sitka spruce (*Picea sitchensis*), aspen (*Populus tremuloides*), and birch (*Betula papyrifera*) on well-drained soils, with black spruce (*Picea mariana*) forests and woodlands occurring in wetter areas. These tall scrub communities with willow and alder (*Alnus rubra*) occur along the shores of the Chakachamna River in the Prospecting Permit Area (ADF&G 2006). Forests grade into tall shrub communities of willow (*Salix alaxensis*) and alder (*Alnus rubra*) at higher elevations on the periphery of the basin (Wiken et al. 2011). The terrestrial landforms support moist tundra, with brush vegetation on lowlands. Spruce and hardwood forests dominate the landscape, but the rolling topography of the region support diverse vegetation. Uplands have mixed forests of white and Sitka spruce, aspen, and birch trees.

2. Riparian Habitats

The Chakachatna River is a major tributary of the MacArthur River. These rivers supply fresh water to the large tidal flat expanse designated as the Trading Bay State Game Refuge and into Cook Inlet. The Prospecting Permit Area is within the general distribution areas for ducks, swans, and geese; and is located near fall concentration areas as well as nesting and molting concentration areas which are located to the east downstream of the Prospecting Permit Area (ADF&G 1985a).

There are four anadromous fish streams that flow into Chakachamna Lake: the Neacola, Igitna, Chilligan, and Nagishlamina rivers. Chakachamna Lake is located southwest of Mount Spurr, to the west of the Prospecting Permit Area, and just east of the Lake Clark National Park boundary. It is approximately 14 miles long and 2.5 miles wide from north to south at its widest point near the mouth of the Nagishlamina

River. It is largely fed by glacial rivers. It is an interesting body of water as at its head is an entrapped lake called Shamrock Lake that is formed by a large glacial moraine from the receding Shamrock Glacier. Chakachamna Lake provides spawning and rearing habitat for sockeye salmon (*Oncorhynchus nerka*) (Johnson and Blossom 2019).

Chakachamna Lake feeds into the Chakachatna River which flows through the southern portion of the Prospecting Permit Area (ADF&G 2020k). The Chakachatna River supports spawning populations of chum salmon (*Oncorhynchus keta*), rearing populations of coho salmon (*Oncorhynchus kisutch*), rearing populations of sockeye salmon, and Chinook (*Oncorhynchus tshawytscha*) and pink salmon (*Oncorhynchus gorbuscha*) are also present. Additionally, there are rearing populations of Dolly Varden (*Salvelinus malma*) in and around the Prospecting Permit Area. To the east of the Prospecting Permit Area, Straight Creek and its unnamed tributary support spawning and rearing of chum, king, pink, sockeye and coho salmon, as well as Dolly Varden (ADF&G 2020k).

3. Designated Conservation Areas

The Trading Bay State Game Refuge, encompassing approximately 160,960 acres, is located about 10 miles downstream to the east of the Prospecting Permit Area. The Trading Bay wetlands provide critical spring feeding, summer nesting, and fall staging habitat for thousands of ducks, geese, swans, and cranes. It was created in 1976 “to protect fish and wildlife populations; waterfowl nesting, feeding, and migration; moose (*Alces americanus*) calving areas; spring and fall bear feeding areas; salmon spawning and rearing habitats; public use of fish and wildlife (waterfowl, moose, and bear hunting); viewing; photography; and general recreation in a high-quality environment” (ADF&G 1994).

As spring break-up moves inland, waterfowl disperse throughout the Trading Bay State Game Refuge area to nest. Several species of ducks inhabit the area and use it for nesting grounds including the mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), green-winged teal (*Anas carolinensis*), wigeon (*Mareca Americana*), shoveler (*Anas clypeata*), common eider (*Somateria mollissima*), mergansers (*Mergus merganser*), scaup (*Aythya marila*), and goldeneye (*Bucephala clangula*). Loons (*Gavia spp.*), shorebirds, and bald eagles (*Haliaeetus leucocephalus*) also nest in the Trading Bay State Game Refuge (ADF&G 2020g).

The Redoubt Bay Critical Habitat Area is located to the south of the Prospecting Permit Area. The Redoubt Bay Critical Habitat Area was created in 1989. It lies on the west side of Cook Inlet immediately to the south of the Trading Bay State Game Refuge and covers approximately 171,500 acres. The purpose of the designation is “to ensure the protection and enhancement of fish and wildlife habitat and populations; the continuation of fish and wildlife harvest; and public use and enjoyment of the area in a high-quality environment” (ADF&G 1994).

The Redoubt Bay Critical Habitat Area provides spring and fall resting and feeding habitat for hundreds of thousands of waterfowl on their way to and from nesting grounds to the north. In summer months, the area is an important waterfowl nesting area for ducks, geese, swans, among other birds. The area's wetlands are also heavily used by tundra (*Cygnus columbianus*) and trumpeter swans (*Cygnus buccinator*), cackling Canada geese (*Branta hutchinsii*), and snow geese (*Chen caerulescens*). During snow free months, it supports the largest known concentration of Tule white-fronted geese (*Anser albifrons gambeli*) in the world (ADF&G 2020f).

In the summer, the Redoubt Bay Critical Habitat Area is home to several tens of thousands of breeding ducks including pintail, mallard, green-winged teal, wigeon, scaup, canvasback (*Aythya valisineria*), and common eider. Yellowlegs (*Tringa melanoleuca*), snipe (*Gallinago gallinago*), godwits, whimbrels (*Numenius phaeopus*), several species of sandpipers (*Scolopacidae spp.*), plovers (*Charadriinae spp.*), dunlin (*Scolopacidae spp.*), and phalaropes (*Phalaropus spp.*) inhabit the critical habitat area in summer months as well. Bald eagles (*Haliaeetus leucocephalus*), ravens (*Corvus corax*), gulls (Larus spp.), and passerines (*Passeriformes spp.*) can also be seen in the area during spring, summer, and fall. Additionally, sandhill cranes (*Grus canadensis*) migrate through the area and some stay and nest each year (ADF&G 2020f).

B. Fish and Wildlife Populations

1. Fish

Chinook (king) salmon are the largest of the Pacific salmon species at maturity, commonly exceeding 30 pounds (ADF&G 2008). They return to Cook Inlet area streams from early May through July. Females lay 3,000 to 14,000 eggs (Armstrong 1996). After hatching and emerging from the gravel, juvenile Chinook feed on plankton and insects while in freshwater (ADF&G 2008). Most Chinook salmon remain in freshwater for one or two years before their seaward migration, and they spend three to five years in the ocean (Armstrong 1996).

Sockeye (red) salmon are unique in that after emerging from the gravel, they usually spend one to two years in lakes as juveniles (Armstrong 1996). Between 2,000 and 5,000 eggs are deposited in one or more "redds", which the female digs with her tail over several days. Important food sources in lakes include plankton and insects. Some populations of sockeye, called kokanee, remain in lakes for their entire life cycle. After two or three years at sea, mature sockeye return to their native streams as early as May and runs continue through August (ADF&G 2020j). Sockeye salmon spawn in beach gravels as well as streambeds and juveniles typically rear in lake habitats for one to three years before out-migrating to saltwater. Lake systems tend to be more productive than river systems for this species (ADF&G 2020k, j)

Coho (silver) salmon begin entering rivers and streams in mid-July and remain in streams through December, with the peak runs occurring from August to October (ADF&G 2020d). Females deposit from 2,400 to 4,500 eggs in stream gravel (Armstrong 1996). Most coho remain in freshwater until the following spring. During fall and winter, juvenile coho seek out off-channel habitat where the risk of flooding is lower. The amount of time they spend at sea varies as some males (called jacks) mature and return after only 6 months at sea at a length of about 12 inches, while most fish stay 18 months before returning as full size adults (ADF&G 2008).

Pink (humpback) salmon are the smallest of the five species of Pacific salmon. They return to freshwater to spawn from early July through September in the Cook Inlet area (ADF&G 2020i). Pink salmon generally spawn in the lower reaches of streams within a few miles of the ocean and may even spawn in intertidal areas (ADF&G 2008). Females deposit from 1,500 to 2,000 eggs in the gravel of spawning streams (Armstrong 1996). Juvenile pink salmon do not rear in freshwater. Rather, after emerging from the gravel, they immediately migrate downstream. Young pink salmon form large schools in estuarine areas where they remain for several months before migrating out to sea in the fall (ADF&G 2008). Pink salmon remain at sea for one year, feeding mainly on zooplankton, squid, and fish (Armstrong 1996).

Because pink salmon migrate to sea shortly after emerging from the gravel and spend only one year at sea, they have a distinct two-year life cycle from egg to spawning; therefore, populations are characterized as either odd- or even-year (ADF&G 2008).

Chum (dog) salmon are found in many systems of the Cook Inlet area including in the Prospecting Permit Area. Runs begin in mid-July and continue through mid-August. On average, females lay 2,000 to 4,000 eggs (Armstrong 1996). After hatching in the spring, young chum immediately migrate to the ocean. They form large schools and remain in estuaries and near-shore waters feeding on plankton until fall, when they migrate to the open ocean. After three to six years at sea, chum return to their home streams to spawn (ADF&G 2008).

Dolly Varden are found in many rivers and streams in the Prospecting Permit Area. They are closely related to Arctic char (*Salvelinus alpinus*) and distinguishing between the two requires close examination. Generally, Arctic char have fewer and larger spots, a more deeply-forked tail, and a narrower caudal peduncle (the area before the tail fin) than Dolly Varden (ADF&G 2019b). Although Dolly Varden generally spawn in the fall, their life history is notoriously variable. The female will deposit between 600 and 6,000 eggs in redds, which she digs in the streambed gravel with her tail. Among freshwater residents, there are lake, stream, and dwarf forms. After their first migration to the ocean, generally after 2 to 4 years in freshwater, Dolly Varden may spend the remainder of their lives overwintering in lakes and migrating between the ocean and fresh water (ADF&G 2008). Their life span can be up to 18 years, but usually it is less than 10 years. In freshwater, Dolly Varden eat unburied salmon eggs, aquatic insects, and crustaceans (Armstrong 1996).

2. Birds

Bald eagles are a common and visible raptor in the Prospecting Permit Area. These birds are protected by the federal Bald Eagle Act of 1940, which makes possession of an eagle, either alive or dead, illegal (ADF&G 2008). The Bald Eagle Act of 1940 further protects bald eagles making it illegal to take or disturb an eagle nest (16 U.S.C. 668 – 668c). In 2007 the bald eagle was removed from the threatened and endangered species list, although Alaska's bald eagles were not listed and the population remains healthy (ADF&G 2020a). Based on limited surveys the bald eagle population in Alaska is estimated at 70,500 birds and is considered to be increasing slowly and projected to remain stable (USFWS 2016). Bald eagles are usually found near shorelines and river areas, as well as near prominences used for perches and nests (ADF&G 1985a). Fish are the main diet of bald eagles, and they also prey on waterfowl, small mammals, and carrion. They tend to congregate along salmon-spawning streams and shorelines where they search for stranded or dead fish. Bald eagles also take live fish from lakes and streams (ADF&G 2008).

Bald eagles nest in trees that are close to water, with a clear view of the surrounding area, often in old cottonwoods. They tend to use and rebuild the same nest. Nest building begins in April, and two to three eggs are usually laid by late April. Eggs hatch after about 35 days, and eaglets leave the nest after about 75 days. Bald eagles reach sexual maturity at about four or five years of age (ADF&G 2020a).

Golden eagles (*Aquila chrysaetos*), also protected by the Bald Eagle Act of 1940, are found in the Prospecting Permit Area. The adult body color is usually dark brown, and the dark-tipped tail is either darkly barred or spotted. Immature golden eagles have white wing patches and white at the base of the

tail. They have a wingspan up to 7 feet and weigh 8 to 12 pounds. Golden eagles lay a clutch of two eggs from late April through May. Up to 100 days are required for the hatchlings to leave the nests and become independent. Nests are usually located on cliffs, but trees may be used. The golden eagle feeds mainly on ground squirrels, hares, and birds such as cranes, owls, and ptarmigans (ADF&G 2020e).

Golden eagles are capable of killing the young of larger game animals, but few killings have been observed and they also feed on carrion. Golden eagles prefer open habitat and particularly hilly or mountainous regions like the Prospecting Permit Area. Loss of undisturbed habitat seems the most serious threat to maintaining healthy populations of golden eagles. Increasing human disturbance of eagles, and remote area development, pose similar problems for golden eagles as they do for Alaska's bald eagles. Golden eagles are prone to abandoning their nests and young when their nest site has been disturbed by human encroachment. They have a status level of Least Concern with the International Union for Conservation of Nature (ADF&G 2008, 2020e).

Tule white-fronted geese (*Anser albifrons elgasi*), a subspecies of the greater white-fronted goose, inhabit the Cook Inlet area and the Prospecting Permit Area from April through September. The entire population is believed to nest in the upper Cook Inlet Basin (Ely et al. 2006). Tule geese are one of the least abundant goose populations in North America, with a 3-year average of about 14,200 birds during 2016 to 2018 (Olson 2019). In the Cook Inlet region, their average clutch size is five to six eggs (AKNHP 2008). Studies indicate that Tule geese arrive in the Cook Inlet coastal areas and interior marshes from mid-April to early May, and then move to nesting areas. Tule geese start to leave for winter grounds in California by early fall and are gone from Alaska by the end of September (Ely et al. 2006).

Trumpeter swans (*Cygnus buccinators*) are large, all-white birds, with an angular wedge-shaped head and a black bill, legs and feet. Males average 28 pounds and females average 22 pounds. Trumpeter swans mate for life and begin breeding during their third, fourth, or fifth year of life. Nesting begins in early spring, typically in an undisturbed marsh or a small lake. Trumpeter swans prefer secluded regions, where they frequent shallow bodies of water and build their nests in areas of marsh vegetation. After leaving the breeding areas, large numbers of trumpeter swans congregate on ponds and marshes along the coast in late summer and early fall. Most swans depart by mid-October but in some years may remain until freeze-up in November (ADF&G 1985b, a).

Cygnets hatch after a 30 to 35-day incubation period, and they fledge after 11 to 15 weeks. Both the male and female swans guard the nest during this critical time. A young swan eats a high protein diet of aquatic invertebrates and will weigh 21 to 30 pounds as an adult. Trumpeter swans eat foliage, seeds, and tubers of various marsh plants during the summer, and they feed on crops and seeds from agricultural fields on their wintering grounds in the continental United States (ADF&G 2019c). Nesting is widespread in the Trading Bay and Redoubt Bay areas, with the most concentrated use occurring in the drainages of the Kustatan River, Bachatna Creek, North Fork Big River, and the lower Big and Chakachatna rivers. Most breeding pairs are at their nest sites by early May and the first hatching dates range from June 16 to June 29 (ADF&G 2008).

3. Terrestrial Mammals

Moose are present and known to concentrate in the winter along the Chakachatna River downstream to the east of the Prospecting Permit Area (ADF&G 1985a). Their occurrence is likely restricted to lower-elevation alder thickets near the Chakachatna River. Moose are the largest member of the deer family, growing up to 6 feet tall at the shoulder and weighing up to 1,600 pounds (ADF&G 2020h). Moose are commonly found in areas with willow and birch shrubs along major rivers, and on timberline plateaus (Peltier 2017). A female moose typically breeds at about 28 months. After a gestation period of about 230 days, cows give birth to calves annually in the spring. Calves are typically weaned in the fall, and they are chased off before she gives birth again in the spring (ADF&G 2020h). The lowlands of Trading Bay provide important wintering habitat for approximately 500 moose. These may include moose from the hills to the east and west where winter snow depth is too deep to find food in addition to resident animals. Moose calve in bushy riparian habitat throughout the Trading Bay State Game Refuge in spring (ADF&G 2020g).

In 2004, the population of wolves in Unit 16 was estimated between 170 and 240, in up to 22 packs. In 2003, a wolf control implementation plan was initiated in response to declining moose numbers and a high wolf population in Unit 16B. The plan was terminated in 2015. The most recent population estimates are from 2010 for wolves in GMU 16. There were, at that time, an estimated 10-13 wolf packs and 61-106 wolves present in GMU 16 (Brockman and Peltier 2018).

Black bears (*Ursus americanus*) are the most abundant, widely distributed, and smallest of North America's three species of bears. They stand about 29 inches at the shoulder, 60 inches from snout to tail, weigh up to 350 pounds, and range in color from jet black to white. Black bears are distinguished from brown bears (*Ursus arctos*) by their straight facial profile and shorter claws. When black bears come out of hibernation in the spring, they feed on freshly sprouted green vegetation, but they will eat nearly anything they encounter. In the summer, their feeding shifts to salmon if they are available, as well as berries, ants, grubs, and other insects (ADF&G 2020b).

Black bears are found in forested habitat from sea level to the alpine and are prevalent in remote lowland forests and in mountainous valleys (ADF&G 2008). The Prospecting Permit Area is also within the GMU 16 black and brown bear control areas, and the GMU 16B brown bear removal area. The bear control program is authorized under 5 AAC 92.115 and 5 AAC 92.122 with the intent to strengthen the moose population and is separate from the hunting program. The bear control program was suspended on January 1, 2017 (ADF&G 2014, 2019a).

Brown bears are larger than black bears, have a pronounced shoulder hump and smaller ears, and can weigh up to 1,500 pounds. They use their long straight claws to dig up roots and to expose burrowing animals. They feed on sedges, grasses, horsetails, herbs, moose calves, waterfowl eggs and young, spawning eulachon, salmon, cow parsnip, ground squirrels, carrion, roots and berries. Brown bears mate from May to July. Pregnant females usually enter dens first in the fall and emerge last in the spring with their newborn cubs. Cubs are born in the den during January and February with litters of two cubs most common. Adult males usually enter dens last in the fall and emerge first in the spring. Den sites are usually in alpine and subalpine habitats (ADF&G 2020c).

Brown bears forage on the tidal flats each spring and summer and each year from early summer through early fall The Noaukta Slough in Trading Bay supports high numbers of black and brown bears feeding on returning salmon (ADF&G 2020g). Studies in Unit 16B suggest that bear predation also has an influence on moose calf numbers. Black and brown bear surveys were conducted in spring 2007 and indicated a very high density of black bears and brown bears in GMU 16B (Peltier 2017).

Wolves (*Canis lupus*) are also referred to as timber wolves or grey wolves. Over the last 120 years, wolf populations in Alaska have been influenced by various harvest regimes ranging from predator control strategies prior to statehood to relatively restrictive regulations including only trapping and sport hunting. The Prospecting Permit Area is within GMU 16B South, a subdivision of the large and diverse 16B. The increase of wolf predation on moose is believed to have increased over time. In GMU 16, wolf populations have been influenced by various harvest regimes including predator control strategies. Wolf numbers in the unit began increasing in the early 1990s. The department estimated 8-10 wolf packs consisting of 48–62 wolves during the first systematic population estimate of wolves in Unit 16 in March 1993. (Brockman and Peltier 2018).

Wolves are carnivores, and in most of mainland Alaska moose and/or caribou are their primary food, but they supplement their diet with Dall sheep, squirrels, snowshoe hares, beaver, and occasionally birds and fish. A pack may kill a moose every few days during the winter or they may go for several days with almost no food. Typically, one female wolf in a pack has a litter of approximately seven pups each year, and a female wolf is mature enough to breed at 2 years old. Wolves have a relatively high birth rate, but they rarely become abundant because mortality is also high, usually caused by predation by other wolves, or hunting and trapping. (ADF&G 2020l).

Many other furbearers inhabit the Prospecting Permit Area. Healthy populations of coyote (*Canis latrans*), mink (*Neovison vison*), land otter (*Lontra canadensis*), and weasels (*Mustela spp.*) inhabit the wetlands year-round in the Trading Bay State Game Refuge area (ADF&G 2020g). Furbearers present in the Redoubt Bay Critical Habitat Area include coyote, fox (*Vulpes Vulpes*), wolf, mink, river otter (*Lontra canadensis*), marten (*Martes Americana*), muskrat (*Ondatra zibethicus*), wolverine (*Gulo gulo*), weasel, lynx (*Lynx canadensis*), and beaver (*Castor canadensis*) (ADF&G 2020f).

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Chapter Five: Current Uses of the Mount Spurr Area

The land around the Prospecting Permit Area provides habitat for a variety of wildlife and fish species of interest. The unique geology and location of Mount Spurr offer opportunities for scientific research and monitoring of volcanic activity in the Cook Inlet region. State and federally designated parks and preserves near the Prospecting Permit Area are used and valued by residents and visitors to the area. The primary industrial use of the Upper Cook Inlet is for oil and gas exploration and development. Current and projected uses of the disposal area are considered and discussed below.

A. Research and Education

Several Alaska state and federal agencies, along with Alaska's university, conduct research in Cook Inlet. The Alaska Volcano Observatory (AVO) is an interagency program of the Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources, U.S. Geological Survey (USGS), and the University of Alaska Fairbanks Geophysical Institute. AVO monitors Alaska volcanoes, including Mount Spurr, with the purpose of mitigating hazards by providing timely and accurate information on volcanic activity including unrest and eruptions (Schaefer 2020).

AVO monitors Mount Spurr with web cameras, and other ground-based instruments, including seismometers, infrasound networks, and GPS. This monitoring network can provide warning of impending eruptions and serves to provide geophysical data and visual information during active eruptions. It is important to AVO that all monitoring stations located in or near the region of the Prospecting Permit Area not be disturbed physically or through radio interference (Schaefer 2020).

B. Fish and Wildlife Uses and Value

1. Commercial Fishing

Commercial fishing is an important use of natural resources in Cook Inlet to the east of the Prospecting Permit Area. Salmon, Pacific herring (*Clupea pallasii*), and groundfish are harvested in Upper Cook Inlet. In 2019, the Upper Cook Inlet commercial harvest was approximately 2.1 million salmon. This was 37 percent less than the previous 10-year average annual harvest of 3.2 million fish. All five species of Pacific salmon are present in Upper Cook Inlet, sockeye salmon are the most valuable, accounting for nearly 93 percent of the total value during the past 20 years. The estimated sockeye run, based on preliminary data, was 5.2 million fish, or 13 percent less than forecast. The ex-vessel value of the 2019 harvest of all salmon species of approximately $18 million was 40 percent less than the previous 10-year average annual ex-vessel value of $30 million. All species-specific ex-vessel values were below average in 2019 for Upper Cook Inlet (ADF&G 2019). There are 6 commercial fishing permits issued to people from Tyonek that were current at the time of this written finding (CFEC 2020).

The Kustatan Subdistrict includes those waters from the Drift River terminal to the Northern District boundary near the West Foreland which is south of Trading Bay and the closest subdistrict to the Prospecting Permit Area. In 2019, 13 permit holders reported harvest. Over 92 percent of the harvest

typically comes from the Big River sockeye salmon fishery, which empties into Redoubt Bay. The Big River sockeye salmon fishery is an early season fishery occurring from June 1–24. The 2019 sockeye salmon harvest was approximately 7 percent less than the average annual harvest of 3,268 fish during the previous 10 years (ADF&G 2019).

The harvest numbers for Pacific cod (*Gadus macrocephalus*) have declined in recent years. The average total harvest for pot fishing in state waters of Cook Inlet from 2010 through 2017 was 2,886,764 pounds. In 2018 the harvest dropped to 407,088 pounds, then 411,104 pounds in 2019, and in 2020, 393,930 pounds were harvested (ADF&G 2020b). Pacific cod season closed to vessels fishing with pot gear on February 28, 2020, but the less productive jig fishing season remains open in state waters (ADF&G 2020a).

2. Sport Fishing

Sport fishing is also an important recreational use of the Prospecting Permit Area and surrounding waters. Between 2009 and 2018 an average of 11,330 angler days were fished per year in Area N on the west side of Cook Inlet near the Prospecting Permit Area. There was a slight decrease from the 10-year average in 2018 with an estimated 10,533 angler days for the area (ADF&G 2020c). An estimated 1,689 anglers fished the Big River Lakes fishery, reporting 1,774 days fished. They reported harvesting 1,834 sockeye salmon and 1,613 sea run coho salmon in 2018, based on 52 survey responses. Also, in 2018, an estimated 1,443 anglers fished the Kustatan River fishery, reporting 1,945 days fished. They reported harvesting 2,512 sea run coho salmon, based on 41 survey responses (ADF&G 2020d). No sportfishing data from ADF&G was reported for the Chakachatna River in the Prospecting Permit Area.

3. Hunting and Trapping

A total of 248 moose were reported harvested and an estimated additional 42 moose were either unreported or killed illegally in GMU 16B in 2014, the most recent reporting year with available data. The population of moose was estimated at 7,418, which is within the population objective for GMU 16B. The number of harvested moose did not meet the objective of 310-600 moose. During the most recent reporting period, non-resident hunting was reinstated and there are two draw hunts established where the harvest of any bull is permitted to try to increase the harvest numbers. The average general harvest success in GMU 16B was 23 percent (Peltier 2017).

Trapping of furbearers occurs in and around the Prospecting Permit Area within ADF&G's Region IV. Marten, lynx, and wolf were the most important trapped species in 2018, the most recent reporting year where data is available. In 2018, there was a reported 209 marten, 647 lynx, and 336 wolves harvested in Region IV (Spivey 2020).

4. Subsistence Fishing and Hunting

Alaska Native population and non-Natives have been using the fish, wildlife, and plant resources of the Cook Inlet area for subsistence for centuries. Subsistence generally refers to "any harvest or use of fish, wildlife, and wild plants for home use. It also incorporates the noncommercial exchange or sharing of resources…". Under this general definition, detailed information about subsistence uses by residents of

the Cook Inlet area is available for only a few selected communities but is not available for the broader Cook Inlet population (Fall et al. 2004).

All Tyonek households used and attempted to harvest wild resources in 2013. All of the households were successful in harvesting at least one resource. In response to the household surveys conducted in 2014, 88 percent of individuals attempted to harvest a subsistence resource and 92 percent of individuals participated in processing of those resources. The most people in the community participated in the harvest of and processing of vegetation resources which consist of blueberries (*Vaccinium ovalifolium*), currants (*Ribes triste pall*), highbush cranberries (*Viburnum edule*), fireweed (*Chamaenerion angustifolium*), cow parsnip (*Heracleum maximum*), and bluebells (*Mertensia paniculate*) among other plants. Approximately 90 percent of the individuals attempted to gather vegetation resources and 82 percent helped to process those resources. The second most popular subsistence resource activity was fishing. 74 percent of the individuals participated in fishing activities and 81 percent helped to process the fish. 51 percent of individuals participated in a hunt for a large mammal (moose and bear) and 45 percent of individuals helped to process those animals (Jones et al. 2015).

Many households give away or trade these subsistence resources. Of the Tyonek residents in the survey, 86 percent reported receiving a subsistence resource and 78 percent reported giving away at least one resource. Most frequently, Tyonek households reported receiving meat from large land mammals, especially moose. They also reported receiving salmon and other fish, vegetation like berries, birds and eggs, marine invertebrates, and small mammals (Jones et al. 2015).

The Stanek 2007 study found that 95 percent of Beluga residents participated in at least one resource activity and that over 75 percent of residents participated in harvesting and processing fish, mammals, and game birds, and in gathering and processing plants. About half of Beluga households reported that more than half their supply of fish, meat, and birds came from wild sources. Beluga residents used a variety of wild resources, including salmon, rainbow trout (*Oncorhynchus mykiss*), Northern pike (*Esox Lucius*), eulachon (*Thaleichthys pacificus*), brown and black bear, moose, beaver, red squirrels (*Sciurus vulgaris*), ruffed (*Bonasa umbellus*) and spruce grouse (*Falcipennis canadensis*), ptarmigan (*Lagopus muta*), cranes, ducks, geese, berries, and plants (Stanek et al. 2007).

A second study, conducted in 2006, collected detailed information about historical subsistence uses of resources in the area by residents. Residents were interviewed concerning their uses of wildlife, fish, and plants over the last 20 years, from 1987-2006 (SRBA 2007). Details from this study are discussed below.

a. Fish

Tyonek respondents harvest all five species of Pacific salmon (Chinook, coho, sockeye, chum, and pink) as well as other non-salmon fish species, including rainbow trout, Dolly Varden, halibut, and eulachon (Jones et al. 2015). Fishing activities generally occur year-round and are an important part of Tyonek residents' subsistence diet. Residents reported traveling along the road system to the Chuitna River, Nikolai Creek, and Beluga River, and fishing up and downriver from the bridges; some also reported fishing at the mouths of Beluga and Chuitna rivers (SRBA 2007).

Chinook salmon are an important part of the subsistence harvest because of their early arrival and large size. Coho salmon are harvested for both subsistence and commercial sale, whereas sockeye, pink, and

chum salmon are harvested mostly for commercial sale. The Tyonek residents reported harvesting a total of 16,766 pounds of salmon in 2013, consisting of 10,247 pounds of Chinook salmon, 3,169 pounds of coho salmon, 3,088 pounds of sockeye salmon, 151 pounds of pink salmon, and 102 pounds of chum salmon (Jones et al. 2015). In 2018, there were 65 permits issued for the Tyonek subdistrict subsistence salmon fishery including 49 permits to residents of Tyonek. Residents of Tyonek were responsible for 1,308 salmon or 81 percent of the harvest total. In 2018, an estimated 1,100 Chinook, 132 coho, 96 sockeye, and 10 chum were harvested by people in the community of Tyonek. These harvest numbers are slightly lower than the most recent 5 and 10-year average (Jones and Fall 2020). Approximately 230 pounds of rainbow trout, 54 pounds of steelhead, 28 pounds of Dolly Varden, and 14 pounds of Northern pike were harvested for subsistence by the people of Tyonek in 2013 (Jones et al. 2015).

b. Marine Mammals

Federal regulations allow Tyonek residents to participate in traditional hunting of seal and beluga (*Delphinapterus leucas*) in Cook Inlet. The Marine Mammal Protection Act allows NOAA Fisheries to enter cooperative agreements with Alaska Native organizations to conserve marine mammals and co-manage subsistence activities, including beluga whale hunts (NOAA Fisheries 2020). The hunting and use of beluga by the Dena'ina people of upper Cook Inlet, including the village of Tyonek has been documented as an important subsistence resource. Sources noted the high value that Cook Inlet Dena'ina placed on beluga products including beluga meat and oil. Tyonek residents' level of beluga hunting activity has varied over the years, primarily due to changes in resource availability; however, cultural ties have remained strong (SRBA 2011). Decreased beluga population in Cook Inlet have led to the listing of Cook Inlet belugas under the federal Endangered Species Act. In 2007, Tyonek residents joined efforts to help Cook Inlet beluga stocks regenerate by voluntarily agreeing to halt subsistence hunting of the animals in some years. Tyonek residents traditionally hunt beluga in Cook Inlet primarily between the Susitna and Beluga rivers, encompassing an area that stretches from Granite Point to Little Susitna River (SRBA 2007).

Tyonek seal hunting areas extend from the Susitna River south past Harriet Point, with the majority of activity occurring in Cook Inlet between Tyonek and McArthur River and between the Beluga and Susitna Rivers. Residents generally hunt seals in the mouths of rivers or while traveling in open water by boat. However, some reported traveling to the shore or to riverbanks by vehicle and hunting seals from the land (SRBA 2007). Tyonek residents harvested 360 pounds of harbor seal (*Phoca vitulina*) in 2013 with 8 percent of the population attempting, and 6 percent of the population successfully harvesting a total of 6 seals (Jones et al. 2015).

c. Bear

There is no federal subsistence priority or open season for brown bear in GMU 16B. Residents of GMU 16B which include people living in Tyonek and Beluga can harvest up to 3 black bear year-round. Regulations require that the hide, claws, and edible meat be salvaged from a black bear. Bait may be used to hunt black bear between April 15 and June 15 (USFWS 2018a). Tyonek residents reported hunting both black and brown bear. Respondents reported hunting bear in many of the same areas where they hunt moose during the fall season, along the McArthur River and on the local road system (SRBA 2007).

Tyonek residents provided the locations of key bear habitat, primarily denning areas. The majority of observed bear dens were in the Bald Hills and Lone Ridge area. Tyonek respondents also indicated that upon emerging from their dens, bears are near salmon spawning streams and in areas abundant with moose (SRBA 2007). In 2013, 4 percent of the Tyonek population attempted a subsistence hunt for black bear and 2 percent attempted a subsistence hunt for brown bear, but no bears were harvested according to the survey data (Jones et al. 2015).

d. Moose

In 1983, the Alaska Board of Game affirmed customary and traditional use for moose and established subsistence hunting regulations for moose in GMU 16B. The winter was determined to be essential subsistence hunting season in the area because of the availability of moose locally, timing of customarily take, and ease of preservation. GMU 16B was subdivided and one subunit was established in the Tyonek area. In the Tyonek area, 29-37 moose are determined to be reasonably necessary per year under 5 AAC 99.025(8). The fall harvest and winter subsistence and winter Tier II hunts remains in regulation for moose in GMU 16B (Van Larnen et al. 2019).

Tyonek residents reported hunting moose in an area extending from the Lewis River south to the McArthur River and west toward Lone Ridge and the foothills of Mount Spurr. A number of residents focus on hunting moose, particularly in the area south of Tyonek, on several roads and trails that follow the Chakachatna River and extend toward the Bald Hills. A number of people set up camps near Chakachatna River and hunt moose further off-road by four-wheeler, as well as using tree stands built along the road system (SRBA 2007). Residents of GMU 16B are allowed to harvest one bull moose in the Redoubt Bay drainages and in the Kustatan River drainage area between September 1 and 15. In the rest of GMU 16B outside of Denali National Preserve, one bull is the harvest limit in the month of September and from December 1 through February 28 (USFWS 2018a).

The residents of Tyonek and Beluga reported a preference for the winter moose hunt for their subsistence needs. They also prefer the Tier II regulations for any bull because they prefer the meat from a young bull over an older bull with 50-inch antler spread (Van Larnen et al. 2019). Factors that contribute to an important area to harvest moose include harvest success, family and cultural value of an area, distance from the village, and ease of access. Tyonek respondents explained their preferences for hunting areas such as the McArthur and Chakachatna Rivers, often pointing to their distance from human activity as a primary reason (SRBA 2007). In 2013, 59 percent of the survey respondents from Tyonek reported attempting a subsistence moose hunt and 12 percent of the people were successful harvesting a total of 3,471 pounds of moose meat (Jones et al. 2015).

e. Furbearers and Other Small Land Mammals

Residents of Tyonek reported hunting and trapping furbearers and small land mammals, including beaver, wolf, wolverine, mink, and marten. Residents also hunt beaver, porcupine, and hare for their meat. Hunting and trapping areas extend from the Lewis River to the McArthur River and inland toward the Bald Hills. Residents commonly reported hunting beaver along the McArthur River during the fall moose hunting season (SRBA 2007). In 2013, only beaver, snowshoe hare, and porcupine were harvested according to the report totaling just under 140 pounds of meat. 12 percent of the people responding to the survey reported that they attempted to harvest small land mammals, and 6 percent were successful.

Beaver represented the majority of the harvested meat at 77 pounds and 52 pounds of porcupine (*Erethizon dorsatum*) meat were reportedly harvested (Jones et al. 2015).

f. Waterfowl

Tyonek respondents reported hunting waterfowl in three main areas: Trading Bay, Chuitna River, and the flats west of Susitna River. A number of respondents reported harvesting waterfowl during fall moose hunting trips along the above-mentioned waterways. Residents generally reported hiking substantial distances to harvest waterfowl. Tyonek subsistence users reported hunting both spruce grouse and ptarmigan throughout the year. Respondents indicated that they often hunt upland birds when they are available during other subsistence pursuits or when residents are traveling along the road system, rather than taking separate trips to harvest them (SRBA 2007). In 2013, Tyonek residents harvested a total of 166 pounds of bird and egg subsistence resources with 31 percent of the people responding to the survey attempting to harvest and 29 percent of them successfully harvesting birds or eggs. They harvested 35 pounds of mallard ducks, 35 pounds of spruce grouse, 26 pounds of unknown geese, and 23 pounds of Northern pintail (Jones et al. 2015).

Federal regulations allow Tyonek residents to participate in traditional spring and summer hunting of waterfowl. The season is open April 2nd until May 31st and again from August 1st to August 31st. The regular hunting season begins in September. September represents the highest number of waterfowl hunts, over twice as many as any other month (SRBA 2007).

g. Plants

Firewood is gathered throughout the year, but wood gathering intensifies around October. Gathering of edible plants such as wild celery (*Apium spp.*), wild rhubarb (*Koenigia alaskana*), and rosehips (*Rosa acicularis*) occurs during the summer. Tyonek residents harvest a variety of berries each summer and fall, including blueberries, cranberries, cloudberries (*Rubus chamaemorus*), currants, crowberries (blackberries) (*Empetrum nigrum*), and salmonberries (*Rubus spectabilis*). Some residents reported harvesting enough berries to last through the summer and into the winter. Residents reported harvesting berries close to the village, along the main road system, and on smaller logging and “seismograph” roads or trails. Residents reported harvesting berries during moose hunting trips along the road system, especially near the Chakachatna River and McArthur River. They pick berries primarily during the months of July and August, although some will pick into September and October (SRBA 2007).

In 2013, Tyonek residents harvested a total of 1,352 pounds of vegetation for subsistence. About 84 percent of the residents responding to the survey harvested vegetation resources. They reported gathering 155 gallons of blueberries, 134 pounds of highbush cranberries, 16 gallons of lowbush cranberries (*Vaccinium oxycoccos*), 5 gallons of currants, 5 gallons of strawberries (*Fragaria vesca*), 4 gallons of raspberries (*Rubus arcticus*), and just over 1 gallon of crowberries (Jones et al. 2015).

Most Tyonek subsistence activities occur near the coast and in the McArthur River floodplain. A few moose, black bear, and brown bear are harvested from the Mount Spurr area; however, the Prospecting Permit Area is outside of important subsistence hunting zones. Therefore, Tyonek subsistence should not be directly affected by geothermal development at Mount Spurr. Geothermal development could indirectly affect Tyonek subsistence if new Mount Spurr residents, people employed and stationed at a

potential geothermal exploration site, hunt in areas currently used for subsistence. Roads between Tyonek and the Chakachatna River would likely be improved if geothermal development occurs.

While improved access could provide greater hunting opportunities for Tyonek residents, improved access, in conjunction with increased regional population, could also increase competition for wildlife. In general, development of lands and resources is expected on the west shore of Cook Inlet. This development may have an impact on the traditional lifestyles of the indigenous people of the area due to the potential presence of geothermal working crews and exploration activities. Geothermal development and support facilities will likely be 30 to 40 miles from Tyonek, and contact between Tyonek residents and geothermal employees should be minimal (Tyonek Native Corporation 2020b). Further, Mitigation Measure 7.c. requires the permittee's employees to be informed of the environmental, social, and cultural concerns of the Prospecting Permit Area. Such orientation should help increase understanding of community values, customs, and lifestyles and mitigate any negative effects.

5. Recreation and Tourism

Recreational use of the Prospecting Permit Area is limited due to its remote location and the hazards associated with the Mount Spurr Volcano. Most of the area around the Mount Spurr volcano is uninhabited wilderness, although it is occasionally visited by small groups of people in summer and winter. There are no roads within the Prospecting Permit Area, and access is restricted to small aircraft or boat (Waythomas and Nye 2002).

6. Energy and Infrastructure

This Prospecting Permit is one of many developmental activities occurring in the Cook Inlet region. Ongoing activities include oil and gas exploration and development in Cook Inlet, and gas-fired electric power generation at Beluga. Some major proposed projects that are in the vicinity of the Prospecting Permit Area include the Pebble Mine Project, Donlin Gold Mine Project, and continuing oil and gas leasing both in state and federal waters. These projects do not coincide with the Prospecting Permit Area but may share some of the infrastructure and have an effect on the shared natural resources of the region.

The Mount Spurr region is not connected by permanent road to the Alaska highway system. A winter trail from Tyonek to the Parks Highway provides the only surface access route to other road-accessible parts of the state. Although nearshore Cook Inlet is shallow, the region is accessible by boat. Approximately five miles south of Tyonek in North Foreland, there is a barge facility containing a barge landing, pier, and docking facility. The North Foreland Barge Facility, LLC is a joint venture between Tyonek Native Corporation and Alaska Village Initiatives. With its strategic location, the landing is a preferred site for the oil and gas industry to transport in and out on the west side of Cook Inlet (Tyonek Native Corporation 2020a). Airstrips are maintained at Beluga and Tyonek though they are both privately owned; lakes and river bars are also used for alternative landing sites (Air Nav 2020b, a).

Oil and/or natural gas is being produced from 13 platforms in Cook Inlet, including locations at nearby Trading Bay and Granite Point to the east of the Prospecting Permit Area. Chugach Electric Association operates a gas-fired power plant, which provides electricity to Anchorage. The power plant is located approximately 7 miles northeast of Tyonek at Beluga. It produces approximately 332 megawatts of electricity from seven units that were first commissioned in 1968 (Chugach Electric Association 2020).

Commercially promising coal deposits are present between Mount Spurr and Tyonek, and coal development may occur in the region known as the Chuitna Coal Project. This project as proposed would have been the largest strip mine in Alaska, but in 2017 the permitting process was halted and plans for development were put on hold (Hollander 2017).

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Chapter Six: Geothermal Resources in the Prospecting Permit Area

A. Geology

Mount Spurr is an active snow- and ice-covered stratovolcano located on the west side of Cook Inlet; its most recent eruption occurred on September 16, 1992. Crater Peak, a small stratocone located about 2 miles from the summit on Mount Spurr's south flank, was the site of the 1992 eruption and an eruption in 1953. It has been the active vent throughout most of the past 6,000 years (Waythomas and Nye 2002).

The peak elevation of Mount Spurr is just over 11,000 feet altitude and has glaciers extending down the valleys from its peak. The oldest rocks of the region are banded schistose rocks that are abundant in the glacial moraines of the area and are believed to be of pre-Mesozoic age. Eocene age Tertiary sedimentary rocks are present between the mountain and the coast. The volcanic rocks range in age from early Tertiary to recent deposits (Capps 1929).

B. Geothermal Energy Potential

Geothermal energy potential in the area is indicated by a discontinuous zone of weak thermal activity, including warm seeps, springs, and fumaroles, extending from south of Crater Peak to north of Mount Spurr (Wescott et al. 1985). The most recent manifestation started in 2004 with increased heat flux at the summit of Mount Spurr, resulting in the creation of a melt-water lake. By March 2006, approximately 5.4 million cubic meters of melt-water volume had resulted from this increased heat flux in the area. This may have been the result of non-eruptive shallow-level magmatic intrusion beginning in mid-2004 (Coombs et al. 2006).

The first State of Alaska geothermal lease sale was held in 1983. Sixteen tracts were offered in the Mount Spurr area but only one received a bid; nine years later, in 1992, this tract was terminated. In 1985, geophysical, geological, and geochemical surveys were conducted by the Alaska Division of Geological and Geophysical Surveys (DGGS) in the Mount Spurr area to explore for accessible geothermal energy resource prospects. Correlations between anomalous concentrations of mercury and helium in soil samples and self-potential and controlled-source audio-magnetotelluric resistivity (CSAMT) measurements were interpreted to mean that a geothermal reservoir having sufficient volume and temperature to warrant further investigation might exist (Wescott et al. 1988).

One warm-spring and a series of seeps in a canyon on the southwest side of Crater Peak were first reported during this same study. The measured temperature of the warm spring and seeps was approximately 40°C. Total warm water flow for the entire valley bottom was estimated at 1,000 liters per minute (Wescott et al. 1988). Geothermal fluids were not directly sampled during this study and thermal spring waters from the flank of Crater Peak were too thoroughly mixed with meteoric water to permit estimation of reservoir temperature using standard chemical geothermometry. In 1986 two new tracts in the Mount Spurr area were offered in the second State of Alaska geothermal lease sale; both tracts

received bids but were subsequently terminated following lease expiration in 1990 and 1996, respectively. The global collapse of oil prices beginning in the mid-1980s has been cited as the primary reason for lack of development of the resource in the 1980s and 90s (Paraskova 2020; Horne and Tester 2014).

The third State of Alaska geothermal lease sale was held in 2008. As was the case 25 years earlier, sixteen tracts were offered in the Mount Spurr area; however, the result was much different. Every tract received a bid and several received multiple bids. Fifteen tracts were awarded to Ormat Nevada (Ormat), a special purpose subsidiary of Ormat Technologies Inc. Amy MacKenzie, an attorney for Ormat at the time, told Petroleum News in 2008 that rising energy prices and dwindling gas supplies in the Cook Inlet area made the prospect of a Mount Spurr geothermal development attractive (Bailey 2008). Following lease acquisition Ormat performed non-intrusive geochemical sampling and geophysical data acquisition during the summers of 2009 and 2010. Using these field results, two shallow (<1,000 ft) exploration wells were drilled in late summer 2010 yielding positive results. In summer 2011 a third deep (nearly 4,000 ft) exploration hole was drilled yielding less than desirable results. Temperatures were much cooler than expected, in part because Ormat was unable to drill through the West Foreland conglomerate into the harder (and presumably hotter) basement rock beneath (ORNI-46 2012). This was a major setback for Ormat and was the main driver which, ultimately, led to the decision to relinquish their leases in 2016 and leave Alaska.

There is, however, at least one additional option that Ormat decided not to pursue: to drill on leases further to the west and closer to the volcanic center where the likelihood of encountering higher temperatures is greater. But with this comes higher risk of pyroclastic flows, lahars, debris flow-avalanches, dome collapse, lava flows, tephra fallout and volcanic outgassing during active volcanic events, all of which could result in damage to production facilities and infrastructure and/or loss of life (Waythomas and Nye 2002).

Active volcanoes are substantial sources of geothermal energy. The potential for discovery and development of exploitable resources in the Mount Spurr area has long been considered worthy of further investigation, as witnessed by the previous geothermal exploration and development lease sales held in 1983, 1986, and 2008. The multifaceted geoscience investigation by the DGGS in 1985 (Wescott et al. 1985), and Ormat's efforts during the summers of 2009, 2010, and 2011 (ORNI-46 2012) to conduct exploration work, which included drilling two shallow wells and one deep exploration well on their Mount Spurr leases, have added to a growing data set and knowledge base for determining geothermal potential at Mount Spurr. Because of persistent ice cover and the steep and dangerous topography at higher elevations, the previous three lease sales have offered acreage located only on Mount Spurr's southern flank. The Prospecting Permit Area consists of a subset of acreage offered during the 2008 lease sale.

There have been several changes related to Cook Inlet basin remaining natural gas reserves and associated economics of development, as well as changes to environmental considerations globally since Mount Spurr tracts were last disposed of in the 2008 geothermal lease sale. First, in 2008, there were nearly 1.5-trillion cubic-feet of remaining natural gas reserves in the Cook Inlet basin and the associated natural gas price was much less than today's market price.

Currently there are less than 1-trillion cubic-feet of remaining natural gas reserves and the cost of development continues to increase. Second, Cook Inlet basin natural gas reserves represent an essentially

closed market, causing higher local natural gas prices when compared to the Lower-48 where domestic natural gas prices have plummeted in response to bringing massive production volumes online in the last ten years. Finally, the effects of climate change recognized today, particularly in the Arctic, are also starting to change the economic landscape for geothermal and other alternative energies. While the average price of natural gas in the United States is currently below $3/MCF, in the Cook Inlet the price is closer to $8/MCF (EIA 2020; Brehmer 2016). These three changes, taken together, point to the prudence of starting now a more diversified energy portfolio in Alaska going forward. Geothermal is one potentially viable alternative.

C. Geothermal Resource Development

Geothermal resources are reservoirs of hot water that exist at varying temperatures and depths below the Earth's surface. Geothermal hot water and steam can reach the earth's surface in the form of hot springs, geysers, mud pots, or steam vents. Geothermal wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications, including electricity generation, heating and cooling, and the heat energy can be used for generating electricity or for direct uses such as heating buildings, greenhouses, and industrial processes (USDOE 2020; BLM 2020). To be extractable, geothermal resources must be trapped in reservoirs relatively near the surface of the earth.

Geothermal features can be observed in areas of active or inactive volcanoes. Subsurface magma heats groundwater, creating steam and hot water. The resulting hot, less dense water rises through faults, fissures, and cracks in the ground. On the surface, hot springs, geysers, fumaroles, and mud pits are created (NPS 2020).

Hot springs in active volcanic zones may produce superheated water and geysers. Geysers are hot springs where the water boils over creating a stream of hot water or steam into the air. In non-volcanic areas, the temperature of rocks within the Earth also increases with depth. This temperature increase is known as the geothermal gradient. Fumaroles are geothermal features resulting from interactions of released volcanic gases and the groundwater system. These occur in areas where a magma conduit passes through the water table and heat from the magma causes water to become steam. Mud pits or mudpots are surface features that occur when geothermal water is mixed with mud and clay. Acid and bacteria in the water can dissolve rock forming pools of bubbling mud (NPS 2020).

Hot springs and fumaroles are indicative of near-surface geothermal resources. Recently active volcanoes are also indicative of geothermal sites. Alaska's approximately 140 volcanoes (one-third of which are active) and more than 90 hot springs provide tremendous potential for geothermal energy development, except that the vast majority of these sites are located far from population centers (DGGS 1983). However, the relatively close proximity of Mount Spurr to the Southcentral Alaska power grid makes the Prospecting Permit Area exceptionally viable as a geothermal energy production site.

Construction of geothermal power plants is capital intensive. On the other hand, like other renewable energy sources, geothermal plants have few additional long-term costs in comparison to fuel-based electric power plants. They bear no fuel costs or associated transportation costs, and operation and maintenance costs are relatively minor. Despite the high capital costs, a typical geothermal plant's lifetime

operating costs are much less than that of a diesel-powered facility of equivalent capacity (Yanity and Kolker 2006).

D. Transportation of Geothermal Resources and Generated Power

Transporting geothermal energy can present challenges. Currently it must be used or converted to electricity within a few miles of its recovery from the ground reservoir. Compared to other energy sources, geothermal resources can only be transported a short distance using conventional technologies.

Long term planning for building feasible energy producing projects includes evaluating transmission distances and the availability of infrastructure from the project area to the main power grid. Geothermal resources can increase the capacity of existing main power grids (Fleischmann 2010).

The Beluga power plant is the nearest power plant and is located on the west side of Upper Cook Inlet near Tyonek, about 40 miles northwest of Prospecting Permit Area. The geographic, technological, and economic aspects of proposed development are major factors influencing transportation systems for the potential geothermal resource and the electrical power generated from it.

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Chapter Seven: Governmental Powers to Regulate Geothermal Exploration and Development Activities

Geothermal exploration activities are subject to numerous federal, state, and local laws, regulations, policies, and ordinances in addition to the provisions of the Prospecting Permit. The permittee is obligated to comply with all federal, state, and local laws. Regulatory agencies may have different roles in the oversight and regulation of geothermal exploration activities, and some agencies may have overlapping authorities with other agencies. Some common activities requiring prior authorization include construction of pads, roads, support facilities, and drilling wells. Additionally, constructing and operating processing facilities or transmission lines would also require prior authorization.

This chapter is not intended to provide a comprehensive description of the broad spectrum of government agencies authorized to prohibit, regulate, and condition geothermal activities that may ultimately occur because of this disposal. Actual processes, terms, conditions, and required authorizations will vary with time-certain, site-specific operations, and the activities discussed in this finding are not all inclusive. Some, but not all, of the major permits and approvals required by each agency are listed below.

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Alaska, Department of Natural Resources Division of Oil and Gas (DO&G)	Plan of Operations Approval 11 AAC 83.158 and 11 AAC 83.346	DO&G reviews and potentially approves Plan of Exploration and Plans of Development for activities on Geothermal Prospecting Permits and Leases.	An application for approval of a plan of operations must contain sufficient information for DO&G to determine the surface use requirements and impacts directly associated with the proposed operations. The operator is required to keep the area open for inspection by authorized state officials. Several state agencies including the Alaska Department of Natural Resources (DNR), Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADF&G), and Alaska Oil and Gas Conservation Commission (AOGCC) may monitor field operations for compliance with each agency's terms.
DO&G	Land Use Permits 11 AAC 96.010, 11 AAC 96.210, 11 AAC 96.030(a), and 11 AAC 96.060	DO&G issues land use permits, also known as a geophysical permit or a miscellaneous land use permit. Geophysical exploration permits are required for all geophysical and exploration activity.	Permits contain measures to protect the land and resources of the area. A bond is required to conduct seismic work. The application must contain the following information in sufficient detail to show evaluation of the planned activities' effects on the

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
			land: (1) a map of sufficient scale showing the general location of all activities and routes of travel of all equipment for which a permit is required; (2) a description of the proposed activity, associated structures, and the type of equipment that will be used.
Alaska, Department of Natural Resources Division of Mining Land and Water (DMLW)	Land Use Permits and Utility Easement Purpose and applicability – 11 AAC 51.010 Standards and Public Easements – 11 AAC 51.015 Application Fee – 11 AAC 05.070.	DMLW-Southcentral Regional Land Office issues easements for uses such as utility lines on state land. An application is required, and a bond may be required.	The application must include the completed Easement Application Form with signature, a written development plan, a map or sketch that depicts the detailed location of the proposed use, Environmental Risk Questionnaire, Permits are subject to conditions to protect fish and wildlife habitat, recreation, navigation, sanitation or water quality, prior appropriators, or any other purpose DNR determines is in the public interest.
DMLW	Temporary Water Use Authorization 11 AAC 93.035 Permit to certificate and appropriate water 11 AAC 93.120 and 11 AAC 93.130 Water Use Act AS 46.15	DMLW administers temporary water use authorizations as required before (1) the temporary use of a significant amount of water, (2) if the use continues for less than five consecutive years, and (3) the water applied for is not otherwise appropriated. Permits are issued for a period consistent with the public interest and adequate to finish construction.	Water permit/certificate to appropriate water. The authorization may be extended one time for good cause for a period of time not to exceed five years. Permits are subject to conditions to protect fish and wildlife habitat, recreation, navigation, sanitation or water quality, prior appropriators, or any other purpose DNR determines is in the public interest.
DMLW	Material Sale Contract 11 AAC 71	DMLW requires a material sale contract if the operator proposes to use state-owned gravel or other materials for construction of pads and roads.	The contract must include, at a minimum, a description of the sale area, the materials to be extracted, the volume of material to be extracted, the method of removal of the material, the bonds and deposits required of the purchaser, and the purchaser's liability under the contract. The material sale contract must also include the purchaser's site-specific operating requirements
Alaska, Department of Natural Resources Division of Parks and Outdoor Recreation Office of History and Archaeology (OHA)	National Historic Preservation Act of 1966 AS 41.35.010	OHA performs the work of the State Historic Preservation office and follows the state's historic preservation plan in maintaining the Alaska Heritage Resources Survey (AHRS).	The Permittee and contractor are required to preserve and protect the historic, prehistoric, and archaeological resources of the state, ensuring they are properly subject of concerted and coordinated efforts exercised on behalf of the general welfare of the public so these resources may be located, preserved, studied, exhibited, and evaluated.

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Alaska, Department of Environmental Conservation (ADEC)	Permits for Interference with Salmon Spawning Streams and Waters AS 16.10.010	ADEC is responsible for issuing permits for activities that interfere with salmon spawning streams and waters. Activities that may potentially obstruct, divert, or pollute waters of the state used by salmon in the propagation of the species, or that may interfere with the free passage of salmon must first apply for and obtain a permit before beginning any work	The applicant may be required to construct and maintain adequate fish ladders, fishways, or other means by which fish may pass over, around, or through the dam, obstruction, or diversion in the pursuit of spawning.
ADEC	Wastewater Disposal Permits 18 AAC 72	ADEC requires a wastewater disposal permit to ensure domestic graywater is disposed of properly at the surface.	Monitoring records must be available for inspection, and a written report may be required upon completion of operations.
ADEC	APDES Discharge Permits and Certification AS 46.03.100, AS 46.03.120(b) 40 CFR §§123.22-23	ADEC regulates discharges of pollutants into US waters by “point sources,” such as industrial and municipal facilities. The APDES covers a broad range of pollutants, which include any type of industrial, municipal, and agricultural waste discharged into water	Permits are designed to maximize treatment and minimize harmful effects of discharges. General permits cover multiple facilities that have similar wastewater characteristics in a defined area. Individual permits are issued to a single facility and the terms, limits, and conditions are specifically tailored for that facility and circumstances.
ADEC	Air Quality Permits Clean Air Act (42 U.S.C. §§ 7401-7671 et seq.) State Implementation Plan (AS 46.14; 18 AAC 50)	Federal requirements of the Clean Air Act are met, including National Ambient Air Quality Standards (NAAQS), Non-Attainment New Source Review (N-NSR), New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and Prevention of Significant Deterioration (PSD). Additionally, ADEC monitors air quality and compliance.	A permitting program required for new construction projects or modifications to an existing facility, ensures that air quality is not degraded by the new project, and that large new or modified industrial sources are as clean as possible
ADEC	Title I Construction Permits Article 3 and 5 of 18 AAC 50 Title V Operations Permits Article 3 of 18 AAC 15 Other Requirements 20 AAC 25.235(c)	Title I permits refer specifically to air construction permits and minor source specific permits for the PSD program as well as other requirements of the Clean Air Act. This permit must be obtained before onsite construction may begin. ADEC is responsible for issuing Title V permits and making compliance inspections (AS 46.14; 18 AAC 50). The permit establishes limits on the type and amount of emissions, requirements for pollution control devices and prevention activities, and requirements for monitoring and record keeping. ADEC also operates ambient air quality monitoring networks under the PSD program to assess compliance with NAAQS for carbon monoxide, particulates, nitrogen dioxide, sulfur oxide, and lead; assesses ambient air	ADEC will decide whether to issue a final Title I permit after taking into consideration any comments received during the public comment period. The final permit package includes a final Technical Analysis Report and response to comments if applicable. A permittee has up to one year after beginning operations to submit a complete Title V permit application. Operations can continue while ADEC processes the application if the application is both timely and complete. Operators in Alaska are required to minimize the volume of gas released, burned, or permitted to escape into the air.

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
		quality for ambient air toxics levels; provides technical assistance in developing monitoring plans for air monitoring projects; and issues air advisories to inform the public of hazardous air conditions	
ADEC	Solid Waste Disposal Permit 18 AAC 60	ADEC regulates solid waste storage, treatment, transportation, and disposal	A comprehensive disposal plan is required and includes specific engineering design criteria and a discussion demonstrating how the various design features (liners, berms, dikes) will ensure compliance with regulations.
ADEC	Industry Oil Discharge Prevention and Contingency Plans AS 46.04.030 AS 46.04.040 18 AAC 75.335 18 AAC 75.425	ADEC regulates spill prevention and response. Oil discharge prevention and contingency plans (contingency plans) must be filed with ADEC before beginning operations. DNR reviews and provides comments to ADEC regarding the adequacy of these contingency plans.	Discharges of oil or hazardous substances must be reported to ADEC. The report must record the volume released, whether the release is to land or to water, and whether the release has been contained by secondary containment or a structure. Contingency plans must describe existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation.
Alaska Department of Fish and Game (ADF&G)	Fish Habitat Permits AS 16.05.841–.871	ADF&G has the responsibility to properly protect freshwater anadromous fish habitat and provide free passage for anadromous and resident fish in freshwater bodies. ADF&G also regulates activities that are conducted below the ordinary high-water mark of an anadromous stream.	ADF&G may attach additional stipulations to any permit authorization to mitigate potentially negative impacts of the proposed activity.
ADF&G	Special Area Permit AS 16.20 5 AAC 95	ADF&G may require a special area permit for activities that may impact fish, wildlife, habitats, or existing public use in any State game refuge, sanctuary, or critical habitat area designated by the Alaska legislature that provide exceptional habitat for wildlife and allow the general public an opportunity to recreate in high quality environments located near the Prospecting Permit Area.	ADF&G may require a mitigation plan when deemed necessary. ADF&G may require aircraft to fly at minimum elevations and distances from state game refuges and critical habitat area boundaries, ADF&G may impose additional flight restrictions and may require a mitigation plan
Alaska Oil and Gas Conservation Commission (AOGCC)	Permit to Drill AS 31.05.090 20 AAC 25.005	AOGCC is authorized to issue permits to drill. Any permittee wishing to drill a well for geothermal resources must first obtain a permit to drill from AOGCC. This requirement applies to exploratory, stratigraphic test and development wells, and injection and other service wells related to oil, gas, and geothermal activities.	After issuance of a permit to drill, information on the surface and proposed bottom-hole locations and the identity of the lease, pool, and field for each well is published as part of the AOGCC's weekly drilling report
US Environmental Protection Agency (EPA)	Resource Conservation and Recovery Act (RCRA)	RCRA establishes criteria governing the management of hazardous waste. Any hazardous waste generated at a facility is subject to the hazardous	Regulations set the parameters for transporting, storing, and disposing of hazardous wastes and for designing and operating treatment,

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
	of 1976 42 USC 6901 et seq. 40 CFR §§ 264	waste regulations administered by EPA.	storage, and disposal facilities safely.
EPA	Air Quality Permits	ADEC administers the federal Clean Air Act and the air quality program for the State of Alaska.	See ADEC above.
EPA	National Pollutant Discharge Elimination System (NPDES)	ADEC administers this EPA program within state waters	See ADEC above.
US Army Corps of Engineers (USACE)	Section 10 Permit Applications 33 U.S.C. 401, et seq.; 33 U.S.C. 403	USACE has regulatory authority over construction, excavation, or deposition of materials in, over, or under navigable waters of the United States, or any work which would affect the course, location, condition, or capacity of those waters (Rivers and Harbors Acts of 1890 (superseded) and 1899	USACE considers conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and other factors judged important to the needs and welfare of the people. Permits may also be reviewed by other agencies, such as EPA, U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS), to ensure compliance with the Endangered Species Act (ESA), the National Environmental Policy Act, and Essential Fish Habitat Provisions of the Magnuson-Stevens Act.
USACE	Section 404	Under Section 404 of the Clean Water Act, USACE regulates discharge of dredged and fill material into waters of the United States including wetlands	Section 404 permits cover activities that potentially discharge fill materials into waters of the United States. Geothermal exploration activities that may require Section 404 permits could include placement of gravel fill for roads, drill site and facility pads, and bridge pilings in wetlands, floodplains, streams and rivers.
US Fish and Wildlife Service (USFWS)	Incidental Take Permits	USFWS has management authority for migratory birds, threatened and endangered species, the national wildlife refuge system, aquatic resources, and landscape conservation. USFWS issues incidental take permits under the ESA.	Incidental take permits with respective habitat conservation plans are required when non-federal activities will result in take of threatened or endangered species.
Alaska National Interest Lands Conservation	Alaska National Interest Lands Conservation Act (ANILCA) of 1980	For any federal determination to "withdraw, reserve, lease, or otherwise permit the use, occupancy or disposition of public lands," an evaluation of subsistence uses and needs must be completed.	ANILCA Section 810 Analysis
Kenai Peninsula Borough (KPB)	Title 21 of the KPB Code	The borough planning commission is responsible for administering the borough's planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use.	Under Title 29 of the Alaska Statutes, home rule and second-class boroughs shall provide planning, platting, and land use regulation on an areawide basis (AS 29.40.010, AS 29.35.180).

Chapter Eight: Reasonably Foreseeable, Effects of Geothermal Exploration, Leasing and Subsequent Activity

The director's decision that disposal of a geothermal prospecting permit best serves the state's interest is contingent upon analysis of the potential effects of the disposal, both adverse and beneficial. Many of the potential adverse effects are avoidable, and the state imposes laws and regulations for this purpose. Some adverse effects are unavoidable. Of those, most can be mitigated by measures imposed by the state; a few must be anticipated and balanced against the beneficial effects. This section of the director's best interest finding outlines the activities likely to occur as a result of this disposal. It also discusses the potential environmental, social, and economic effects and the measures that will be imposed to mitigate adverse effects. The magnitude of disposal effects will depend upon whether commercial geothermal resources are discovered and produced, the location of such resources, the type and extent of facilities necessary for development, and the effectiveness of mitigation measures in negating undesirable impacts.

Potential effects of the geothermal resource's exploration and development at Mount Spurr can be both positive and negative. Potential positive effects may be development of renewable energy sources for Alaska industries and residents. Many of the negative impacts can be prevented, reduced through mitigation measures. However, mitigation measures cannot prevent or reduce all negative impacts from activities in an area with an active volcano. DO&G mitigation measures are in Chapter Nine.

Until the prospecting permit is issued, and discoveries are made, DO&G cannot predict when any geothermal activity may occur or the type, location, duration, or level of these potential activities. In addition, methods to explore for, develop, produce, and transport geothermal resources will vary depending on the area, permittee, operator, and discovery. The director is not required to speculate about possible future effects subject to future permitting (AS 38.05.035(h)). However, future effects will be analyzed at the time that applications for those future phases are submitted to the state. See Chapter Seven for a description of governmental powers to regulate geothermal exploration and development activities.

Work conducted in the exploration and drilling stages of developing a geothermal resource are similar to those of the oil and gas industry. However, the subsurface characteristics of geothermal resources can significantly limit their effectiveness. During exploration work, the oil and gas industry has to locate resources in geological regimes similar to geothermal (i.e. oil or gas shale), and opportunities for technology transfer between the industries are expected (GEA 2009). This chapter discusses similar potential effects for geothermal exploration, development, production, and transportation.

Prospect permitting for geothermal exploration is not expected to have any significant effects, other than to provide a small initial revenue to the state. Post permitting and disposal activities could affect the terrestrial and freshwater habitats and wildlife, birds and fish of the disposal area and uses of these resources. These activities could include seismic surveys related to exploration and development; environmental and other studies; excavation of gravel material sites; construction and use of support

facilities such as gravel pads, staging areas, roads, airstrips, pipelines, and housing; transportation of machinery and labor to the site; and construction of drill sites and ongoing production activities.

A. Potential Effects on Habitats, Fish, and Wildlife

Activities used for exploration, such as seismic surveys, road and other construction activities, and ongoing vehicle and human movements may impact or alter landscapes and habitats. These activities may disturb the environment and contribute to behavior changes in wildlife and birds. The extent to which geothermal exploration affects the environment is proportional to the scale of its execution. Generally, the environmental effect is more significant in plants with geothermal direct-use applications. Although the consequences of pollution may be high, the probability of such events is considered low (Berrizbeitia 2014). Below is a discussion of potential effects from activities such as surface land disturbances, seismic surveys, road and pad construction, and similar activities on terrestrial habitats, fish, and wildlife in and near the disposal area.

1. Potential Effects on Terrestrial and Aquatic Habitats

During geothermal exploration, development, and production, various activities can impact vegetation and habitats in the Prospecting Permit Area. Direct habitat loss can result from construction of well pads, pipelines, roads, airfields, processing facilities, housing, and other infrastructure. Effects of constructing pads, roads, and pipelines on habitats can include direct loss of acreage due to gravel and materials infilling, and loss of habitat due to entrainment and diversion of water. The discussion below addresses impacts that may occur from geothermal resources exploration and recovery activities.

In initial exploration phases for geothermal resources, disturbances caused by cross-country travel and construction are the most significant. These disturbances related to construction of roads and pads, and mobilization of equipment are comparable to the impacts studied during oil and gas construction activities. Human activities can damage or remove the vegetative cover, leading to soil erosion. Searching for adequate construction materials can also cause removal of gravel, if available, and disturbance of habitats. Land surface disturbances may change and destroy vegetation and can alter soils characteristics (Hanley et al. 1983, 1981).

Disturbances to the environment from the construction of roads and pads have diverse effects on many aspects of terrestrial and aquatic ecosystems. The ecological effects of these types of disturbances can be observed substantial distances from the road or pad in ecosystems, creating habitat fragmentation and facilitating ensuing fragmentation through support of development activities. Roads have several general effects including mortality from road construction, mortality from collision with vehicles, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, and spread of exotics (Trombulak and Frissell 2000).

Disturbances and development work can change soil density, temperature, soil water content, light levels, dust, surface waters, patterns of runoff, and sedimentation, as well as adding heavy metals (especially lead), salts, organic molecules, ozone, and nutrients to the natural environment. The effects of these physical disturbances include habitat loss or fragmentation and threatening or extinction of populations and species near the road edge, mortality of wildlife on roads, the use of road edges as habitat, and dispersal of wildlife along road networks. Mitigation of negative impacts can be accomplished with

appropriate measures, such as road edge management, containment of water run-off, and planning of roads to minimize habitat fragmentation and loss (Spellerberg and Morrison 1998).

Numerous studies have demonstrated declines in stream health associated with roads and development of infrastructure. The nature and extent of land use within a region tend to be correlated with the extent of the road networks. However, it is often difficult or impossible to separate the direct ecological effects of roads from those of the accompanying land-use activities (Trombulak and Frissell 2000).

The major facilities that may be constructed in the post-lease phase of development are a processing facility and a power generation plant. The sites selected for these facilities should be planned to prevent or mitigate negative effects to terrestrial habitats and the wildlife, birds and vegetation found there (Kagel et al. 2007). Any subsequent activities in the exploration, development, and production phases must be applied for independently. See the description of governmental powers to regulate geothermal exploration and development activities outlined in Chapter Seven.

As geothermal resources are identified, infrastructure construction may be needed. Development and production generally require construction and continued use of support facilities including production pads, airstrips, facilities, and living quarters for field personnel. In addition to clearing trees for construction, facilities may also require placement of gravel fill, and impoundment and diversion of water. Cumulative effects are primarily related to habitat impacts that include direct loss through cover by facilities and functional losses through habitat alteration and behavioral displacement away from facilities (Child 2007; Northrup and Wittemyer 2013).

Most geothermal power plants require a large amount of water for cooling or other purposes. This could increase conflicts with fish spawning and rearing in areas where water is in short supply. Steam vented at the surface may contain hydrogen sulfide, ammonia, methane and carbon dioxide. Dissolved solids discharged from geothermal systems include sulfur, chlorides, silica compounds, vanadium, arsenic, mercury, nickel and other toxic heavy metals. All these releases, if concentrated, can create localized fish and wildlife kills. However, geothermal resource development is often extremely compact and centralized, so reducing their environmental impacts to an acceptable level is achievable (USFWS 2018).

Geothermal development poses only minimal impact to wildlife and vegetation in the surrounding area when compared with other alternative sources of energy extraction and production. It should be noted that geothermal facilities must sometimes be built in more sensitive areas. Geothermal plants are designed to minimize the potential effect upon wildlife and vegetation: pipes are insulated to prevent thermal losses, power plants are typically fenced in so as to prevent wildlife access, spill containment systems with potential to contain the maximum spill are put in place, and areas with high concentrations of wildlife or vegetation specific to an area are avoided (Concerto 2017).

In 2010 and 2011, Ormat showed that disturbance and construction projects can be minimized. Little to no vegetation was cleared to install the base camp and the 2010 drill sites. The 2011 sites were cleared of dominantly alders, which has cleared opening for future re-growth of willow, potentially improving migratory bird habitat. Personnel and equipment were transported approximately 35 miles by helicopter from the village of Tyonek to the base camp and drill sites on Mt. Spurr, further minimizing the potential effects on the local environment (ORNI-46 2012).

2. Potential Effects on Birds

Effects of disturbances on birds, and specifically the effects of aircraft traffic, have been studied for several species, locations, and types of aircraft with varying results. Studies regarding the impact of low altitude overflights by helicopter or other aircraft traffic can adversely affect birds by causing stress and the flushing of habitats and nests. Research relating to aircraft disturbances of birds showed that aircraft noise and the presence of aircraft flying below 1000 ft altitude caused head-bobbing behavior or flushing of part or all of a bird colony. Helicopters can cause more disturbance due to their low altitude capabilities. Flushing and displacing adults or broods from preferred habitats during pre-nesting, nesting, and brood rearing and migration can cause disruption of courtship, chick loss, egg breakage, and predation by predators (Rojek et al. 2007).

In a four-year study by Ward et al. (1999), the effects of aircraft overflights were observed on Pacific brant and Canada geese in Izembek Lagoon, located in Southcentral Alaska. The findings showed that 75 percent of the Pacific brant and 9 percent of the Canada geese flew in response to overflights. The Pacific brant were more reactive to helicopter rotary wing aircraft (51 percent) and louder aircraft (49 percent), as compared to fixed-wing (33 percent) and low-noise aircraft (40 percent). The Canada geese were more reactive to helicopter rotary wing aircraft (41 percent) and louder aircraft (43 percent), as compared to fixed-wing (20 percent) and low-noise aircraft (31 percent). The greatest response was to flights at intermediate altitudes of about 1000 to 2300 feet. Lateral distance from the birds was also a critical factor in determining the amount of disturbance to the birds (Ward et al. 1999).

3. Potential Effects to Fish and Wildlife

Because the Prospecting Permit Area is located at a relatively high elevation, few animals reside in the tracts. Although geothermal exploration could disturb moose, black bear, and other wildlife species, such disturbance would be temporary. However, geothermal development could result in permanent displacement of these animals from part of the Prospecting Permit Area because development may affect many acres. Environmental disturbances from development projects can alter animal behavior by causing changes in their physiological state, home ranges, reproductive success, and escape response. Not all species and ecosystems are equally affected by development projects, but overall the introduction of new roads and infrastructure is correlated with changes in species composition, population sizes, and hydrologic and geomorphic processes that shape aquatic and riparian systems (Spellerberg and Morrison 1998; Trombulak and Frissell 2000).

Geothermal well spacing can be dense—up to one well per two acres—and wells are connected by gathering lines to power plants. Development could therefore present a network of well pads and pipelines possibly displacing large mammals from the developed area. Mitigation Measure 1.c. prohibits facilities within 500 feet of all fish-bearing streams and water bodies. Mitigation Measure 1.g. is designed to allow free movement and safe passage of mammals. Temporary wildlife displacement may occur due to power line construction should a geothermal development yield a marketable quantity of electricity. Relatively few large mammals reside in the Prospecting Permit Area, and because of the mitigation measures in place, any displacement from the developed areas is expected to have a minor effect on regional populations of animals.

Chakachamna Lake and Chakachatna River are important salmon habitat. If geothermal wastewater were to enter the Chakachamna-Chakachatna system, the fishery resource could be impacted. More information is presented below in Section A.6, A.7, regarding fuel and produced water releases, and Section B regarding water quality. Additional potential effects to fish and wildlife are discussed in Section D regarding noise. Mitigation measures in section 4 prohibit the discharge of produced waters into freshwater bodies and require the disposal of produced waters to be by subsurface disposal techniques, require spill protection and contingency planning and require appropriate storage and transfer of all environmental contaminants on site to prevent any release to the environment.

B. Potential Effects from Geothermal Activities

1. Seismic Surveys

Geophysical methods used in geothermal exploration can be divided into four main groups, depending on the physical parameters measured: potential methods, electrical and electromagnetic methods, seismic methods, and radiometric methods. Good geophysical surveys are usually based on a combination of methods (Georgsson 2009).

Seismic methods measure sound velocity distribution and anomalies in the earth as well as attenuation of the sound waves. They are divided into two groups, active methods where an external source is used to create sound waves, and passive methods that detect the seismic activity in the earth, and use that to get information about the geothermal system. Passive methods use the natural seismic activity to delineate active faults and permeable zones or to locate the depth to the heat source. Active methods study the behavior of artificially generated elastic waves in the subsurface. A seismic wave or pulse is generated at the surface by an active seismic source. This can be important for the understanding of the geothermal activity in the measured area (Georgsson 2009).

Potential effects from seismic surveys could occur through direct impacts to fish and eggs or embryos or through habitat degradation at stream crossings. Bank and riparian vegetation damage are more likely to result in cumulative effects on freshwater habitats. Vegetation damage may increase input of fine sediment to streams that can smother salmon and trout eggs in redds and reduce primary and secondary productivity that contribute to overall reduced growth and survival of fish (Bash et al. 2001).

Advances in geophysical methods and seismic technologies extended their applicability to studies of geothermal aquifers. For example, in central Poland, new technologies were used to identify that the geothermal reservoir is located deep underground in both the Lower Cretaceous and the Lower Jurassic sedimentary successions. Seismic surveys support the selection of an optimal location of geothermal investment and determination of the geometry of geothermal aquifer, can contribute to the reduction of estimation error of groundwater reservoir temperature, and optimizes the drilling targets (Mackowski et al. 2019).

Effects from seismic surveys during any season could be substantial if operations are conducted improperly. Wildlife can be particularly sensitive to disturbance during nesting periods, but disturbances during winter when food resources are limited can be more problematic. Seismic surveys within the Prospecting Permit Area may be conducted during winter or summer and have the potential to disturb wildlife in the vicinity of the surveys (Linnell et al. 2000).

2. Well Blowouts

During geothermal drilling, highly pressured steam and fluids can be encountered, and there is potential for blowouts. When the pressure in the well hole is higher than the mud pressure, the flow will move from the potential reservoir into the well, causing a "kick." When this flow is not controlled, it results in a blowout (Finger and Blankenship 2012).

The apparatus that controls a kick and potential outflow at the wellhead is called the blowout preventer (BOP) or blowout prevention equipment (BOPE). The BOP stack is comprised of four types of devices to shut off the wellbore and prevent fluid flow out of it: annular preventers, pipe rams, blind rams, and shear rams. The basic function of each is to shut off the wellbore, but they operate in slightly different ways. Below the BOP stack, the choke and kill lines are connected to the wellhead so that fluids can be either released from or pumped into the wellbore as part of the well-control process. The primary method of detecting a kick is to compare measurements of the drilling fluid inflow and outflow (Finger and Blankenship 2012).

If a blowout occurs, the pressure release may impact the immediate area, and gas vapors may migrate downwind. Potential explosions and the possibility of fire are immediate hazards if a blowout occurs. Blowouts can also cause a toxic cloud of hydrogen sulfide to accumulate close to the ground. Released natural gas and condensates that did not burn in the blowout can be hazardous to organisms exposed to high concentrations (Van Dyke 1997).

Other hazards may include exposure to airborne contaminants, noise, heat stress, hazardous chemicals and wastes, and ionizing radiation. Exposure to noise, hydrogen sulfide, hazardous chemicals and wastes, noise and heat are the major occupational health hazards associated with geothermal energy development. Natural gases, hydrogen sulfide, ammonia, metals, hazardous chemicals may impact any humans, plants, insects and other organisms in the area (Frankey et al. 2013).

Loss of well control from blowouts could result in geothermal fluid spills. However, operators will be required by regulation 11 AAC 87.130 to use blowout prevention equipment, which will reduce the probability of spills. The probability of a geothermal well blowout and consequent geothermal fluid spills is low, but the state requires that operators submit and gain approval of a geothermal spill contingency plan from the Alaska Department of Environmental Conservation (ADEC).

3. Drilling Related Oil and Fuel Spills

Geothermal exploration and development projects require the use and storage use of petroleum products and other potential environmental contaminants to fuel heavy equipment and a drill rig. The environmental impact of a spill depends strongly on the size, location, type of fluid, and spread of the spill, including whether it contaminates ground or surface water. Exposure to surface water or groundwater allows a spill to spread further and makes cleanup more difficult. Spilled oil or refined fuel can coat plants, soils, microbes, and animals. Spilled petroleum products can prevent plant growth and hinders the movement of water, oxygen, and nutrients through soils. Some components of oils and liquid fuels are toxic to plants, animals, and humans. Some light oils and refined fuels such as gasoline or diesel may evaporate, releasing toxic fumes that may degrade air quality or pose a fire hazard (Allison and Mandler 2018).

Some other factors that can affect the impact of spilled fuels or oil depend on time of year, vegetation, and terrain. Also, the characteristics of the soil, such as porosity, permeability, texture, degree of water saturation and organic matter content, can affect oil movement (Jorgenson and Cater 1996). Cumulative effects of discharges, leaks, and spills on terrestrial wildlife are related primarily to exclusion from and temporal loss of contaminated habitats, although some individual animals may be lost from toxic effects. Oil spills may result in habitat damage, changes in prey or forage availability, and contamination of prey or forage resources. Changes in preferred prey or forage may lead to displacement into lower quality habitats with reduced prey or forage, which can reduce survival or reproductive fitness (Burns et al. 2014).

The action of removal of spilled fuel or oil may be more damaging than allowing some residual product to remain in place, in some cases. Spill response and cleanup activities could also affect wildlife although effects are not likely to be cumulative. Cleanup operations decrease the likelihood that wildlife encounter petroleum products or contaminated forage or prey, but these activities could temporarily disturb and displace some wildlife.

4. Releases of Drilling Muds and Produced Water

Drilling muds or fluids are a vital component in the drilling process to keep the drill bit lubricated and cool, remove the drill cuttings from the borehole, and counterbalance the formation pressure and prevent a blowout. Drillers use water-based muds most frequently, but oil-based and synthetic muds can be used. Often additives are incorporated into the fluid to adjust the density of the material, and barium sulfate is the most commonly used weighting additive (OSHA 2020). The release of drilling muds, produced water, and solid wastes may affect vegetation, soils, wildlife, birds, and fish. The most commonly spilled fluid during drilling activities is produced water. Produced water is up to 15-times saltier than seawater and can kill vegetation and prevent plants from growing in previously contaminated soil (Allison and Mandler 2018). During geothermal exploration well drilling muds and cuttings are stored on-site, in holding tanks and then hauled to an approved solid waste disposal site or are reinjected into the subsurface at an approved injection well (Finger and Blankenship 2012).

The down-hole injection of drilling muds and cuttings are unimportant as long as they are not placed into the subsurface into a drinking water aquifer. Underground injection techniques for mud and cutting disposal have improved which has greatly reduced the potential adverse impacts caused by releases of drilling muds (NRC 2003). Class II underground injection wells are used for disposal of produced water which is usually a brine (EPA 2017). Mitigation measure 4.l. prohibits discharge of produced waters into freshwater bodies and requires disposal of produced waters by subsurface disposal techniques.

Safety hazards for workers can accompany geothermal drilling when drillers open the drill string to test drilling muds. Hydrogen sulfide and ammonia can be released in harmful concentrations. Some of the drilling materials can be caustic or toxic, and worker safety procedures can help to mitigate any harmful effects (Finger and Blankenship 2012).

5. Induced Seismicity

Geothermal fields are typically located in seismically active areas or along active faults. Although it typically occurs naturally, seismicity has at times been induced by human activity, including the

development of geothermal fields, through both production and injection operations. The resulting seismicity can be low-magnitude events called microearthquakes with magnitudes below 3. These microearthquakes sometimes occur when geothermal fluids are injected back into the system and are centered on the injection site. The microearthquakes sometimes associated with geothermal development are not considered to be a hazard to the geothermal power plants or any surrounding communities (Concerto 2017).

Geothermal fields in tectonically active regions often showed seismicity, but not always of large magnitude. Geothermal systems targeting shallow, porous, low temperature sandstone aquifers on the other hand have not been associated with felt induced seismicity (Buijze et al. 2019).

One study showed that a creep route for induced seismicity from geothermal exploration activity is possible when heterogeneities exist along the fault. Creep is steady fault movement, varying from continuous to episodic with creep events lasting minutes to days. Generally, creep occurs without any associated earthquake activity. Processes associated with geothermal activity might drive seismicity in addition to the effects related to fluid pressure and show that a creep route for induced seismicity is possible (Schmittbuhl et al. 2014). Seven large-scale fluid injections have been performed at an enhanced geothermal production site in France on four deep wells. During all these stimulations, induced seismicity has been extensively studied. At each of the wells, fluid pressure increase has been considered as the main source of seismicity initiation (Shapiro et al. 1999).

Mount Spurr is in an active seismic area, and seismic effects are possible. Increased seismicity could be hazardous to production operations and adjoining land uses. Therefore, the state may install additional seismographs or other instruments in producing fields to detect induced seismic activity. The Alaska Volcano Observatory (AVO) currently monitors the Cook Inlet volcanoes, including Mt. Spurr, with ground-based instruments, including seismometers, web-cameras, infrasound networks, and GPS. This monitoring network can provide warning of impending eruptions and serves to provide geophysical and visual information during eruptions in progress (Schaefer 2020). If geothermal production induces seismicity, and if induced seismicity could be hazardous, the permittee will be required, as necessary, to adjust production and injection rates or to suspend operations under Mitigation Measure 1.m.

6. Mitigation Measures

Contingency plans must detail how operators will prevent, control, and clean up accidental releases of geothermal fluids and other spills of environmental contaminants. Such plans should decrease the risk of a spill in the Prospecting Permit Area. Drill rigs and other facilities may require gravel pads, Mitigation Measure 1.i. prohibits gravel mining within active river floodplains and restricts upland sites to the minimum necessary.

DO&G mitigation measures, along with laws imposed by other federal, state, and local agencies, can minimize many negative effects of geothermal exploration and development activities, and associated infrastructure and roads. However, mitigation measures and laws cannot protect all activities and facilities from the actions of a live volcano like Mount Spurr. DO&G mitigation measures for this Prospecting Permit Area are in Chapter Nine.

C. Water Quality

1. Potential Effects on Water Quality

Geothermal power plants can affect water quality and consumption levels. Geothermal fluids pumped from underground reservoirs often contain high levels of sulfur, salt, and other minerals. Geothermal water may contain boron and other heavy metals at different levels and concentrations. Although geothermal energy is one of a clean and renewable resource, it can lead to contaminated water and soil during electricity production or other processes, if the wastewater is not properly handled (Yilmaz and Ali Kaptan 2017).

The accidental discharge of geothermal fluid into the natural water environment may lead to serious damages. In one study, the impact of geothermal wastewater on surface water has been investigated in the Buyuk Menderes River, Turkey. Thermal return water from district heating were the most important source of major solutes and trace elements to the Buyuk Menderes River and tributaries. The thermal contribution causes a significant increase in sodium, sulfate ions, electrical conductivity, and temperature of surface waters. Longitudinal changes in chemistry were evaluated and revealed that water quality is strongly affected by the contribution of thermal water from the Hudai geothermal field (Davaraz et al. 2017).

An analysis of the Argonne National Laboratory concluded that geothermal waters pose a large potential risk to water quality, if released into the environment, due to high concentrations of toxics including antimony, arsenic, lead, and mercury. However, the risk of release can be virtually eliminated through proper design and engineering controls (Berrizbeitia 2014). Most geothermal facilities have closed-loop water systems, where water is pumped back into the geothermal reservoir after the energy has been extracted from it. In such systems, the water is contained within steel well casings cemented to the surrounding rock (UCS 2013). Except for non-condensable gases, most all chemical effluents are dissolved in geothermal wastewater. Concentration levels of chemical constituents measured in wastewater from a geothermal powerplant indicate that silicon dioxide, arsenic, aluminum, and boron are elevated in geothermal effluents. These elements could potentially affect the communities around the outflow sites (Wetang'ula 2004).

Geothermal wastewater could also be hot, and accidental disposal to surface waters could cause thermal pollution. Temperature directly influences the metabolic rates, physiology, and life-history traits of aquatic species including their productivity. Thermal loads can cause disruption of fish and other aquatic communities. Fluctuation in water temperature can cause behavioral and physiological responses in aquatic organisms. Permanent shifts in temperature regimes can render formerly suitable habitat unusable by native species. In serious cases a permanent increase in water temperature levels can result in high temperature tolerant species to take over the ecosystem (Wetang'ula 2004).

Non-condensable gases, primarily carbon dioxide, form a negligible part of the steam produced from geothermal wells. Hydrogen sulfide may also be present in the steam produced, however, it is routinely diminished at geothermal power plants, resulting in the conversion of over 99.9 percent of the hydrogen sulfide from geothermal non-condensable gases into sulfur. The sulfur byproduct can then be used as a fertilizer (Kagel et al. 2007). Most geothermal reservoirs are found deep underground, well below

groundwater reservoirs. As a result, these deep reservoirs pose almost no negative impact on water quality and use (Concerto 2017).

Total reinjection of wastewater, brine, or condensate from geothermal plants is now required by mitigation measures. The water fraction from the high-pressure separators is typically 75-80 percent of the total flow for liquid dominated reservoirs. Pollution from most sources can be easily circumvented by requiring the proper care and disposal of offending substances (Thorhallsson 2006).

2. Mitigation Measures

Geothermal activities may affect water quality, but mitigation measures regulate the handing of wastewater and outline the requirements of storage and disposal of produced water and wastewater. Per the Clean Water Act, disposal of produced waters will be by subsurface disposal techniques, and surface discharge of reserve pit fluids will be prohibited unless authorized. Solid waste disposal restrictions are addressed by Mitigation Measure 4.i. Mitigation measure 4.l. requires that all produced waters be disposed by subsurface techniques, thus the potential impacts of disposing of geothermal wastewater into surface waters will be prevented. Geothermal drilling and conservation regulations will also help prevent pollution by setting standards for geothermal drilling procedures, including selection of casing, cementing, and blowout prevention.

D. Air Quality

1. Potential Effects on Air Quality

While geothermal energy generates minimal emissions compared to fossil fuels, exploration, development, and operation of this renewable resource would be responsible for minor amounts of air pollutants. Diesel exhaust from construction and drilling equipment and dust from road and well pad construction and use would contribute air pollutants to the region. However, it is expected that any incremental increases in pollution will not have a significant cumulative impact on air quality. The U.S. Environmental Protection Agency (EPA) and ADEC, Division of Air Quality require industries with emissions that may affect air quality to control and reduce their air emissions such that Alaska and national ambient air quality standards are maintained. Emissions from combustion are the primary source of fine particulates (ADEC 2018).

Geothermal exploration and development activities may emit poisonous gases which are a health hazard to employees. For example, hydrogen sulfide is a poisonous gas with a pungent smell similar to that of rotten eggs. Workers exposed to levels higher than the recommended limits of 10 parts per million can get irritated, choked, and eventually die if proper measures are not taken immediately to remove them from the vicinity. Hydrogen sulfide monitoring equipment is worn by personnel on site which can help mitigate this risk. However, the most common hazard according to the study was innocuous dust and exposure to dangerous machinery (Frankey et al. 2013).

The visible plumes seen rising from water cooled geothermal power plants are actually water vapor emissions (steam), not smoke, and are caused by the evaporative cooling system. Air cooled systems emit no water vapor, and thus blend easily into the environment. In a water-cooling process, 50 percent or

more of the geothermal fluid that enters the cooling tower is emitted to the atmosphere as water vapor, while the remainder recycles back into the reservoir (Concerto 2017).

Geothermal plants emit only trace amounts of nitrogen oxides, almost no sulfur dioxide or particulate matter, and small amounts of carbon dioxide. The geothermal sulfur dioxide equivalent, derived from hydrogen sulfide emissions, is one of the most significant pollutants emitted from geothermal power plants which is naturally present in many subsurface geothermal reservoirs. Even so, sulfur dioxide emitted by geothermal facilities, at 0.35 lbs/MWh, represents only a fraction of the 6.04 lbs/MWh of sulfur dioxide generated by the average U.S. power plant. With the use of abatement equipment, however, emissions of hydrogen sulfide are regularly maintained below established standards (Kagel et al. 2007).

2. Mitigation Measures

Geothermal activities may affect air quality. Any geothermal power plants built in the Mount Spurr area as a result of this disposal will be required to use sulfur abatement technologies. Current regulations and abatement technologies should be adequate to prevent significant deterioration of air quality in the Mount Spurr area if geothermal development occurs. Administration of the federal Clean Air Act 42 (USC §§ 7401-7671), and the state air quality statutes and regulations (18 AAC 50, AS 46.03, and AS 46.14), are expected to avoid, minimize, and mitigate those potential effects. Therefore, additional DO&G mitigation measures are not included in this finding; air quality regulations are under ADEC's jurisdiction. Mitigation measures and laws cannot always protect air quality from the actions of a live volcano.

E. Noise

1. Potential Effects of Noise

Noise impacts from geothermal exploration and development are caused by construction operations and subsequent operation of any geothermal facilities. The principal noise sources during construction would be construction equipment. New noise sources during operations could be vehicles and aircraft that would access the geothermal well sites and energy-generating facilities as well as noise from any turbines or other infrastructure. These noise sources would be an intensification of use on land primarily used at present for off-highway vehicle recreational use.

Sound is measured in units of decibels (dB) but for environmental purposes is usually measured in decibels A-weighted (dBA). A-weighting refers to an electronic technique which simulates the relative response of the human auditory system to the various frequencies comprising all sounds. Noise pollution from geothermal plants is typically considered during three phases: the well-drilling and testing phase, the construction phase, and the plant operation phase. During the drilling phase, there are several noise sources including the use of large mud pumps, hydraulic pumps, compressors, and generators. Drilling operations are often conducted 24-hours per day (Hunti 1998).

During construction, noise may be generated from construction of the well pads, transmission towers, and power plant. During the operation stage, the majority of noise is generated from the cooling tower, the transformer, and the turbine-generator building. Construction is one of the noisiest stages of geothermal development, but even construction noise generally remains below the 65-dBA regulation established by the BLM (Kagel et al. 2007).

Chronic and frequent noise such as operating compressors can interfere with an animal's ability to detect important sounds, while periodic, unpredictable noises can be interpreted as threatening (Francis and Barber 2013). If noise becomes a constant stressor, it can reduce reproductive success and long-term survival (FHWA 2004). Noise from geothermal activity can come from the release of fluids and gasses from underground reservoirs when extracted on purpose or as a natural surface expression. Most noise produced from geothermal production comes from the emission of steam under pressure (Hunti 1998).

Furthermore, noise pollution associated with the construction phase of geothermal development, as with most construction, is a temporary impact that ends when construction ends. Well pad construction can take anywhere from a few weeks or months, depending upon the depth of the well. In addition, construction noise pollution is generally only an issue during the daytime hours and is not a concern at night (Kagel et al. 2007). Siting the facilities away from residential locations, site contouring and landscaping, and the implementation of noise barrier fencing, and generator containment buildings are some best practices to help reduce the noise impacts from geothermal exploration, development, and production (Hunti 1998).

Several noise muffling techniques and equipment are available for geothermal facilities. During drilling, temporary noise shields can be constructed around portions of drilling rigs. Turbine-generator buildings are usually designed to accommodate cold temperatures and they are typically well insulated acoustically and thermally. They are also typically equipped with noise absorptive interior walls (Concerto 2017).

2. Mitigation Measures

Under Mitigation Measure 1.a., the plan of operations must describe the operator's efforts to minimize impacts on residential, commercial, and recreational areas. Mitigation Measure 1.b. requires operators to minimize sight and sound impacts for new facilities sited in areas of high commercial, recreational, and subsistence use and important wildlife habitat.

F. Historic and Cultural Resources

1. Potential Effects

If development occurs, impacts and disturbance to the historic and cultural resources could be associated with installation and operation of geothermal resource development facilities, including drill pads, roads, airstrips, pipelines, processing facilities, and any other ground disturbing activities. Damage to undiscovered archaeological sites may include: direct breakage of cultural objects; damage to vegetation and the thermal regime, leading to erosion and deterioration of organic sites; shifting or mixing of components in sites resulting in loss of association between objects; and damage or destruction of archeological or historic sites by spill cleanup crews collecting artifacts. The Prospecting Permit Area contains no documented historic or archeological sites and has a low potential for containing other cultural resources. However, if a site, structure, or object of prehistoric, historic, or archaeological significance is discovered during permit/lease operations, the permittee must report the discovery to the director as soon as possible and take steps to protect it under Mitigation Measure 6.

2. Mitigation Measures

Because historic and cultural resources are irreplaceable, caution is necessary in order to not disturb or impact them. AS 41.35.200 addresses unlawful acts concerning cultural and historical resources. It prohibits the appropriation, excavation, removal, injury, or destruction of any state-owned cultural site. In addition, all field-based response workers are required to adhere to historic properties protection policies that reinforce these statutory requirements, and to immediately report any historic property that they see or encounter (OHA 2020).

DO&G mitigation measures in this finding address education and protection of historic and archeological sites. However, mitigation measures and laws cannot protect all historic and cultural resources from the actions of a live volcano. Refer to Chapter Nine for information about mitigation measures.

G. Potential Fiscal Effects on the State and Communities

The state may permit or lease state-owned land for development of geothermal resources. Disposal and leasing activities alone are not expected to have any effects, other than to provide initial revenue to the state. The related revenue sources include rental and royalty payments. There are currently no active geothermal resource production activities on state land.

Geothermal development at Mount Spurr has potential to have long-term and positive economic effects for the State of Alaska. Future revenue sources to the State that could be derived from the project would be lease rental charges and production royalties outlined in 11 AAC 84.770. Property tax revenues would also accrue to the Kenai Peninsula Borough. Additional economic benefits would result from project spending with potential opportunities for Alaskan firms likely for material, labor, transportation, construction, and other contract services.

Exploration and design phase activities for a Mount Spurr geothermal project would include substantial field, engineering, and additional scientific studies. At-scale, the project infrastructure would be comprised of wells, pipelines, water handling and turbine facilities, roads, 40 miles of power transmission lines to the Beluga power plant, control systems, and personnel housing, transportation, and maintenance facilities. Spending and employment for labor, materials, services, and transportation would likely peak during the development and construction phases, with lesser spending and employment expected during the operational phase of the project.

A successful geothermal development project at Mount Spurr would be a pioneering and challenging project for Alaska and would help to diversify the State's energy supply and economic base. As the State's first volcanic geothermal development, the project would demonstrate the viability of new energy source development in Alaska. The project also has the potential to help establish a geothermal industry in Alaska. Other regions of Alaska have already been identified as having geothermal energy potential.

Finally, an additional economic benefit to State would result from adding electricity capacity to the Cook Inlet region. Currently, electricity is primarily generated for the region by use of natural gas-fired turbines. Reliable and affordable geothermal electricity generation would serve to supplement the current electricity supply in the region and would contribute to the economic wellbeing of Alaskans.

The Alaska Energy Authority rated the state as commercially ready to implement technology. Siting, permitting, and customer markets must overcome the risk of bearing the high exploration and capital investments in the initial development phases. Power plants must be designed to maximize reservoir potential and sustainability. Adequate financing is required for plant and transmission line construction. It is reported that it may take 2 to 3 years to construct a small power plant (2 to 3 megawatts), and 10 years to construct plants exceeding 10 megawatts capacity. Operational costs may be low after power generation begins for properly managed reservoirs and facilities. Operating and maintenance costs for a geothermal power generation facility can range from $15 to $30 per megawatt, or $.015 to $.03 per kilowatt (AEA 2009). The Alaska Energy Authority does not currently fund geothermal power projects in the state, but plans to bring the geothermal program online when funding is available (AEA 2020). These figures are speculative and based on Alaska Energy Authority information on standard expectations. No agreements are in place with a potential producer and the rail belt utilities.

1. Mitigation Measures

The mitigation measures encourage the permittee to employ local Alaska residents and contractors, to the extent they are available and qualified. Operators must submit, as part of the plan of operations, a plan detailing the means by which they will comply with the mitigation measures. The plan must describe the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors to the extent allowed under the Alaska Constitution.

H. Public Access and Other Uses

Continued use of the Prospecting Permit Area for activities such as hunting and fishing will depend on access. Most Tyonek subsistence activities occur near the coast and in the McArthur River floodplain. Moose, black bear, and brown bear are harvested from the Mount Spurr area; however, the Prospecting Permit Area is outside of important subsistence hunting zones. Therefore, Tyonek subsistence should not be directly affected by geothermal development at Mount Spurr. Geothermal development could indirectly affect Tyonek subsistence if geothermal employees or contractors hunt in areas currently used for that purpose. Trails between Tyonek and the Chakachatna River would likely be improved if geothermal development occurs.

While improved access could provide greater hunting opportunities for Tyonek residents, improved access, in conjunction with increased regional population, could also increase competition for wildlife. Increased regional population as a result of this disposal is not expected. In general, development of lands and resources is expected on the west shore of Cook Inlet. This development may have an impact on the traditional lifestyles of the indigenous people of the area by potentially adding pressure on the resources with additional users gaining access to the area. Geothermal development and support facilities will likely be 30 to 40 miles from Tyonek (Tyonek Native Corporation 2020).

1. Mitigation Measures

Mitigation Measure 7.c. requires the permittee's employees to be informed of the environmental, social, and cultural concerns of the Prospecting Permit Area. Such orientation should help increase understanding of community values, customs, and lifestyles and mitigate any negative effects.

Under Mitigation Measure 5.c., public access to the Prospecting Permit Area may not be restricted except within 1,500 feet of drill sites, buildings, or other related facilities. Additionally, no facilities or operations may be located where they would block public access to, or along navigable and public waters as defined in AS 38.05.965(14) and AS 38.05.965(21). If facilities are to be located near public waters, an easement will be reserved under AS 38.05.127 and 11 AAC 51.045 to ensure the right of public access.

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Chapter Nine: Mitigation Measures

AS 38.05.035(e) and the department delegation of authority provide the director of DO&G with the authority to impose conditions or limitations, in addition to those imposed by statutes and regulations, to ensure that a resource disposal is in the state's best interests. Consequently, to mitigate the potential adverse social and environmental effects of specific activities, DO&G has developed mitigation measures and will condition plans of operation, exploration, or development and other permits based on these mitigation measures. Mitigation measures are not intended to duplicate or replace an agency's regulatory authority.

The permittee must obtain approval of a detailed plan of operations from the director before conducting exploration, development, or production activities. These mitigation measures will carry forward and apply if the Prospecting Permit is converted to leases. A plan of operations must identify the sites for planned activities and the specific measures, sequence, and schedule of operations, design criteria, transportation activities, construction methods, and operational standards to be employed to comply with the restrictions listed below. Additionally, a plan of operations must set forth plans for area rehabilitation, mitigation measures, plans to prevent or control the release of hazardous substances, and address any potential geophysical hazards that may exist at the site.

These measures were developed after considering terms imposed in earlier geothermal disposals of state interests, competitive oil and gas lease sales, and comments and information submitted by the public, local governments, environmental organizations, and other federal, state, and local agencies. Additional measures may be imposed on a proposed plan of operations.

The permittee must comply with all applicable local, state, and federal codes, statutes, and regulations, as amended; as well as current or future ADNR area plans and recreation rivers plans; and ADF&G game refuge plans, critical habitat area plans, and sanctuary area plans within which a permit or lease area is located. The effects of future exploration, development, and production will be considered when various government agencies and the public review permit applications and other authorizations for the specific activities proposed at specific locations in the disposal area. Additional project-specific and site-specific mitigation measures may be required by permitting agencies, including DO&G, in response to public comments received during review of the proposed activity or as deemed necessary.

The director may grant exceptions to these mitigation measures. Exceptions will only be granted on a showing by the permittee that compliance with the mitigation measure is not practicable and that the permittee will provide an alternative to satisfy the intent of the mitigation measure. Requests and justifications for exceptions must be included in the plan of operations. The decision whether to grant an exception for a proposed alternative is made during the public review of the plan of operations.

The permittees are notified that mitigation measures may not protect activities and facilities from the effects of Mount Spurr's active volcano.

Abbreviations used are:

Agency	Name
ADF&G	Alaska Department of Fish and Game
ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
DMLW	Division of Mining, Land, and Water (ADNR)
DO&G	Division of Oil and Gas (ADNR)
DPOR	Division of Parks and Outdoor Recreation
EPA	U.S. Environmental Protection Agency
KPB	Kenai Peninsula Borough
NMFS	National Marine Fisheries Service
USCOE	U.S Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

Measurements	Name
ft	feet
mi	miles
in	inches
gal	gallons

A. Mitigation Measures

1. Facilities and Operations

a. A plan of operations must be submitted and approved before conducting exploration, development, or production activities, and must describe the permittee's efforts to minimize impacts on residential, commercial, and recreational areas, Native allotments and subsistence use areas. At the time of application, the permittee must submit a copy of the proposed plan of operations to the KPB and all surface owners whose property will be entered.

b. Facilities must be designed and operated to minimize sight and sound impacts in areas of high commercial, recreational, and subsistence use and important wildlife habitat. Methods may include providing natural buffers and screening to conceal facilities, sound insulation of facilities, or by using alternative means approved by the director.

c. To the extent feasible and prudent, the siting of facilities will be prohibited within 500 feet of all fish-bearing streams and water bodies and 1,500 feet from all current surface drinking water sources. Facilities may be sited within these buffers if the permittee demonstrates to the satisfaction of the director, that site locations outside these buffers are not feasible and prudent or that a location inside the buffer is environmentally preferred. Road, utility, and pipeline crossings must be consolidated and aligned perpendicular or nearly perpendicular to watercourses.

d. The operator must provide a plan to address any potential geohazard impact on operations to mitigate risk to facilities and personnel.

e. Measures will be required to minimize the impact of industrial development on important wetlands. Permittees must identify on a map or aerial photograph the largest surface area, including reasonably foreseeable future expansion areas, within which a facility is to be sited, or an activity will occur. The map or photograph must accompany a plan of operations. To minimize impacts, the permittee must avoid siting facilities in the identified sensitive habitat areas. Further, all activities within wetlands require permission from the U.S. Army Corps of Engineers.

f. With the exception of drill pads, airstrips, and roads permitted under Mitigation Measure 5.a., exploration facilities must be consolidated, temporary, and must not be constructed of gravel unless the director determines that no feasible and prudent alternative exists. Reuse of abandoned gravel structures may be permitted on a case-by-case basis by the director. Approval for use of abandoned structures will depend on the extent and method of restoration needed to return these structures to a usable condition.

g. Where feasible and prudent, onshore pipelines must be located on the upslope side of roadways and construction pads, unless the Director determines that an alternative site is environmentally acceptable. All pipelines must be designed, constructed, and maintained to assure integrity against climatic conditions, tides and current, geophysical hazards, corrosion, and other hazards as determined on a case-by-case basis.

i. Wherever possible, onshore pipelines must utilize existing transportation corridors and be buried where soil and geophysical conditions permit. In areas where pipelines must be placed above ground, pipelines must be sited, designed, and constructed to allow free movement of large mammals. Permittees shall consider increased snow depth in the Prospecting Permit Area in relation to pipe elevation to ensure adequate clearance for wildlife. DO&G may require additional measures to mitigate impacts to wildlife movement and migration.

j. Gravel mining within an active floodplain is prohibited. Gravel mining in upland sites will be restricted to the minimum area necessary to develop the field in an efficient manner.

k. Dismantlement, Removal and Rehabilitation (DR&R): Upon abandonment of material sites, drilling sites, roads, buildings, or other facilities, such facilities must be removed and the site rehabilitated to the satisfaction of the director, unless the director determines that such removal and rehabilitation is not in the state's interest.

l. Wherever possible, transmission lines must utilize existing transportation corridors and must be designed and constructed to minimize impacts to fish and wildlife movement. Minimizing impacts may include burying lines, consolidating stream crossing structures or similar measures.

m. Permittees must conduct a second order survey of the land surface before and during hydrothermal resources production to determine any elevation changes. If production results in subsidence, and if subsidence is determined to be hazardous to geothermal production operations or adjoining land uses, the director will require permittees adjust production and injection rates or to suspend operations.

n. The state may install seismographs or other instruments in producing geothermal fields to detect induced seismic activity. If geothermal production induces increased seismicity and if induced seismicity is determined to be hazardous to geothermal production operations or adjoining land uses, the director, will require permittees adjust production and injection rates or to suspend operations.

2. Fish and Wildlife Habitat

a. The director, in consultation with ADF&G, will impose seasonal restrictions and sound pressure levels on seismic activities in or near fresh water to minimize impacts to fish and marine mammals. The director, in consultation with ADF&G, will impose sound pressure levels for the use of explosives in or near fish bearing streams and lakes. Blasting criteria have been developed by ADF&G and are available upon request.

b. Removal of water from fish-bearing rivers, streams, and natural lakes shall be subject to prior written approval by DMLW and ADF&G.

c. Water intake pipes used to remove water from fish-bearing water bodies must be surrounded by a screened enclosure to prevent fish entrainment and impingement. Screen mesh size shall be no greater than 0.1 inches and the maximum water velocity at the surface of the screen enclosure may be no greater than 0.2 feet per second unless another size or velocity has been approved by ADF&G. Screen material must be corrosion resistant and must be adequately supported to prevent excessive sagging which could result in unusable intake surface. The intake structure must be designed and installed to avoid excessive fouling from floating debris, and a minimum of

eight square feet of effective wetted screen surface must be provided for each multiple of a 450-gallon per minute (one cubic-foot per second) pumping rate. The pump intake opening must be placed equidistant from all effective wetted screen surfaces.

d. Compaction or removal of snow cover overlying fish bearing rivers, streams, and natural lakes shall be prohibited, except for approved crossings. If ice thickness is not sufficient to facilitate a crossing, ice or snow bridges may be required.

e. Surface entry will be prohibited within one-quarter mile of trumpeter swan nesting sites April 1 through August 31. The siting of permanent facilities, including roads, material sites, storage areas, power lines, and above-ground pipelines will be prohibited within one-quarter mile of known nesting sites.

f. Bears:

   i. Before commencement of any activities, permittees shall consult with ADF&G to identify the locations of known bear den sites that are occupied in the season of proposed activities. Exploration and development activities between November 15 and March 31 must not be conducted within one-half mile of occupied brown bear dens, unless alternative mitigation measures are approved by ADF&G. A permittee who encounters an occupied brown bear den not previously identified by ADF&G must report it to ADF&G, within 24 hours. Mobile activities shall avoid such discovered occupied dens by one-half mile unless alternative mitigation measures are approved by the director. Non-mobile facilities will not be required to relocate.

   ii. For projects in close proximity to areas frequented by bears, permittees are required to prepare and implement bear interaction plans to minimize conflicts between bears and humans. These plans should include measures to:

      A. Minimize attraction of bears to drill sites.

      B. Organize layout of buildings and work areas to minimize interactions between humans and bears.

      C. Warn personnel of bears near or on facilities and the proper procedures to take.

      D. If authorized, deter bears from the facilities.

      E. Provide contingencies in the event bears do not leave the site.

      F. Discuss proper storage and disposal of materials that may be toxic to bears.

      G. Provide a systematic record of bears on site and in the immediate area.

g. The director, in consultation with ADF&G shall restrict or modify lease-related activities if scientific evidence documents the presence of Steller's eider from the Alaska breeding population in the area and it is determined that geothermal activities will impact them or their overwintering habitat.

3. Subsistence, Commercial, and Sport Harvest Activities

a. Exploration, development, and production operations shall be conducted in a manner that prevents unreasonable conflicts between lease-related activities and subsistence activities. Lease-

related use will be restricted when the director determines it is necessary to prevent conflicts with local subsistence, commercial, and sport harvest activities. In enforcing this condition, DO&G will consult with other agencies, the affected local borough, and the public to identify and avoid potential conflicts. In order to avoid conflicts with subsistence, commercial, and sport harvest activities, restrictions may include alternative site selection, requiring directional drilling, seasonal drilling restrictions, and other technologies deemed appropriate by the director.

b. Before submitting a plan of operations for either onshore or offshore activities which have the potential to disrupt subsistence activities, the permittee shall consult with the potentially affected subsistence communities and the KPB (collectively "parties") to discuss the siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. The parties shall also discuss the reasonably foreseeable effect on subsistence activities of any other operations in the area that they know will occur during the permittee's proposed operations. Through this consultation, the permittee shall make reasonable efforts to assure that exploration, development, and production activities are compatible with subsistence hunting and fishing activities and will not result in unreasonable interference with subsistence harvests.

c. A discussion of agreements reached or not reached during the consultation process and any plans for continued consultation shall be included in the plan of operations. The permittee shall identify who participated in the consultation and send copies of the plan to participating communities and the KPB when it is submitted to DO&G.

d. If the parties cannot agree, then any of them may request the commissioner, or their designee, to intercede. The commissioner may assemble the parties or take other measures to resolve conflicts among the parties.

e. The permittee shall notify the director of all concerns expressed by subsistence hunters during operations and of steps taken to address such concerns.

f. Traditional and customary access to subsistence areas shall be maintained unless reasonable alternative access is provided to subsistence users. "Reasonable access" is access using means generally available to subsistence users.

4. Fuel, Hazardous Substances, and Waste

a. Secondary containment shall be provided for the storage of fuel or hazardous substances and sized as appropriate to container type and according to governing regulatory requirements in 18 AAC 75 and 40 CFR 112

b. Containers with an aggregate storage capacity of greater than 55 gallons that contain fuel or hazardous substances shall not be stored within 100 feet of a water body or within 1,500 feet of a current surface drinking water source.

c. During equipment storage or maintenance, the site shall be protected from leaking or dripping fuel and hazardous substances by the placement of drip pans or other surface liners designed to catch and hold fluids under the equipment, or by creating an area for storage or maintenance using an impermeable liner or other suitable containment mechanism.

d. During fuel or hazardous substance transfer, secondary containment or a surface liner must be placed under all container or vehicle fuel tank inlet and outlet points, hose connections, and hose ends. Appropriate spill response equipment, sufficient to respond to a spill of up to five gallons, must be on hand during any transfer or handling of fuel or hazardous substances. Trained personnel shall attend transfer operations at all times.

e. Vehicle refueling shall not occur within the annual floodplain, except as addressed and approved in the plan of operations. This measure does not apply to waterborne vessels.

f. All independent fuel and hazardous substance containers shall be marked with the contents and the permittee's or contractor's name using paint or a permanent label.

g. A freshwater aquifer monitoring well, and quarterly water quality monitoring, is required down gradient of a permanent storage facility, unless alternative acceptable technology is approved by ADEC.

h. Waste must be reduced, reused, or recycled to the maximum extent feasible and prudent. Garbage and domestic combustibles must be incinerated whenever possible or disposed of at an approved site in accordance with 18 AAC 60.

i. New solid waste disposal sites will not be approved or located on state property during the exploratory stage of lease activities. Disposal sites may be provided for drilling waste if the facility complies with 18 AAC 60.

j. Impermeable lining and diking, or equivalent measures, such as double-walled tanks, will be required for sewage ponds and sumps. Additional site-specific measures may be required as determined by ADNR and will be addressed in the existing review of project permits or C-Plans. Buffer zones of not less than 500 feet will be required to separate sewage ponds from marine waters and freshwater supplies, streams and lakes, and important wetlands.

k. Proper disposal of garbage and putrescible waste is essential to minimize attraction of wildlife. The permittee must use the most appropriate and efficient method to achieve this goal.

l. All produced water must be disposed to the subsurface to eliminate the potential for contamination of surface water or a drinking water aquifer.

5. Access

a. Onshore activities must be supported by air service, an existing road system or port facility, ice roads, or by vehicles that do not cause significant damage to the ground surface or vegetation. Unrestricted surface travel may be permitted by the director and the director of DMLW, if an emergency condition exists, or if it is determined, after consulting with ADF&G, that travel can be accomplished without damaging the ground surface or vegetation.

b. Construction of temporary roads may be allowed. Temporary means that a road must be removed to the extent that it is rendered impassable or is otherwise rehabilitated in a manner such that any placed gravel remaining approximates surrounding natural features. Construction of permanent roads will be prohibited during the exploration stage.

c. Public access to, or use of, the Prospecting Permit Area may not be restricted, except within 1,500 feet of drill sites, buildings, and other related facilities. Areas of restricted access must be

identified in the plan of operations. Facilities and operations shall not be located so as to block access to or along navigable or public waters, as defined in AS 38.05.

6. Prehistoric, Historic, and Archeological Sites

a. Before the construction or placement of any structure, road, or facility resulting from exploration, development, or production activities, the permittee must conduct an inventory of prehistoric, historic, and archeological sites within the area affected by an activity. The inventory must include consideration of literature provided by the KPB, nearby communities, Native organizations, and local residents; documentation of oral history regarding prehistoric and historic uses of such sites; evidence of consultation with the Alaska Heritage Resources Survey and the National Register of Historic Places; and site surveys. The inventory must also include a detailed analysis of the effects that might result from the activity.

b. The inventory of prehistoric, historic, and archeological sites must be submitted to the director and to the State Historic Preservation Officer (SHPO), who will coordinate with the KPB for review and comment. If a prehistoric, historic, or archeological site or area could be adversely affected by a permit/lease activity, the director, after consultation with SHPO and the KPB, will direct the permittee as to the course of action to take to avoid or minimize adverse effects.

c. If a site, structure, or object of prehistoric, historic, or archaeological significance is discovered during permit/lease operations, the permittee must report the discovery to the director as soon as possible. The permittee must make reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the director, after consultation with the SHPO and the KPB, has directed the permittee as to the course of action to take for its preservation.

7. Local Hire, Communication, and Training

a. The permittee is encouraged to employ local and Alaska residents and contractors, to the extent they are available and qualified, for work performed in the Prospecting Permit Area. Permittee shall submit, as part of the plan of operations, a hiring plan that shall include a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors to the extent allowable under State and federal law. As a part of this plan, the permittee is encouraged to coordinate with employment and training services offered by the State of Alaska and local communities to train and recruit employees from local communities.

b. A plan of operations application must describe the permittee's past and prospective efforts to communicate with local communities and interested local community groups.

c. A plan of operations application must include a training program

   i. for all personnel including contractors and subcontractors;

   ii. designed to inform each person working on the project of environmental, social, and cultural concerns that relate to that person's job;

   iii. using methods to ensure personnel understand and use techniques necessary to preserve geological, archaeological, and biological resources; and

iv. designed to help personnel increase their sensitivity and understanding of community values, customs, and lifestyles in areas where they will be operating.

8. Definitions

In this document:

i. "Facilities" means any structure, equipment, or improvement to the surface, whether temporary or permanent, including, but not limited to, roads, pads, pits, pipelines, power lines, generators, utilities, airstrips, wells, compressors, drill rigs, camps, and buildings.

ii. "Feasible and prudent" means consistent with sound engineering practice and not causing environmental, social, or economic costs that outweigh the public benefit to be derived from compliance with the standard.

iii. "Important wetlands" means those wetlands that are of high value to fish, waterfowl, and shorebirds because of their unique characteristics or scarcity in the region or that have been determined to function at a high level using the hydrogeomorphic approach.

iv. "Minimize" means to reduce adverse impacts to the smallest amount, extent, duration, size, or degree reasonable in light of the environmental, social, or economic costs of further reduction.

v. "Practicable" means feasible in light of overall project purposes after considering cost, existing technology, and logistics of compliance with the mitigation measure.

vi. "Plan of operations" means a geothermal prospecting permit plan of operations under 11 AAC 84.750.

vii. "Secondary containment" means an impermeable diked area or portable impermeable containment structure, or integral containment space capable of containing the volume of the largest independent container. The containment shall, in the case of external containment, have enough additional capacity to allow for local precipitation.

viii. "Temporary" means no more than 12 months.