January 14, 2013

# AUGUSTINE ISLAND GEOTHERMAL RESOURCES DISPOSAL

## Written Finding of the Director

Alaska Department of
NATURAL RESOURCES
DIVISION OF OIL & GAS

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

January 14, 2013

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# Chapter One

# Executive Summary and Director's Final Finding

The State of Alaska, Department of Natural Resources, is offering approximately 65,992 acres in 26 tracts located on and surrounding Augustine Island for geothermal resources disposal (Figure 1.1). 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 the Department of Natural Resources, Division of Oil and Gas (DO&G), has made a final finding that this disposal is in the best interest of the state. The Director reviewed all facts and issues known or made known to him, 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 to him 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 has concluded that the potential benefits of disposing of Augustine Island's geothermal resources outweigh the possible negative effects, and that the disposal is in the best interest of the state of Alaska.

## A. Description of the Proposed Lease Sale Area

The Augustine Island geothermal resources disposal area (Figure 1.1) consists of the entire Augustine Island, including some tidelands and adjacent waters within 3 miles of the island, and excludes nearshore tidelands of the mainland. The island is located near Kamishak Bay on the west side of Lower Cook Inlet, approximately 60 miles southwest of Homer and approximately 180 miles southeast of Anchorage. The disposal area contains about 65,992 acres divided into 26 tracts, ranging from 2,489 to 2,560 acres. The state owns the land and submerged lands within the disposal area.

The area falls entirely within the Kenai Peninsula Borough, however Augustine Island is remote and uninhabitated. The closest cities, towns, villages, and communities in proximity to the area are Homer, Seldovia, Anchor Point, Port Graham, and Nanwalek. Many of the industries and businesses of the area are supported directly or indirectly by natural resources. Industries include oil and gas, manufacturing, coal and timber, commercial fishing, tourism, and government. Cultural and historic resources or archaeological sites are not known to be present on Augustine Island.

The Augustine Island area is mainly characterized by the maritime climate zone. The major watersheds near the area include the Beluga, Chuitna, Nikolai, Chakachatna, McArthur, Tuxedni and Pile rivers. They are located on the mainland and drain into Cook Inlet.

Augustine Island is the site of an active volcano, Augustine Volcano. Geologic hazards may exist on the island, 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. Habitat, Fish, and Wildlife

Augustine Island comprises uplands and wetlands, and is entirely surrounded by the marine waters of Cook Inlet (Figure 1.1).

The terrestrial land forms support moist tundra, with brush vegetation on lowlands on the flanks of the volcano. Numerous wetlands, such as grass and sedge, as well as salt marshes, exist along the coastline of Augustine Island. The limited terrestrial vegetation is not sufficient to support large mammals. No large mammals have been reported on Augustine Island, and there are no data to support the existence of large mammal populations on the island.

The marine habitats of the disposal area extend from the shoreline of Augustine Island to 3 miles offshore. Habitat types include rocky intertidal areas, mudflats and beaches, eelgrass beds, and nearshore, benthic environments. Marine habitats of the area are important to several species of seabirds and shorebirds, fish, sea mammals, and other aquatic organisms.

Most of the area's habitats and populations of fish and wildlife are healthy due to careful management and regulatory mechanisms. A few populations have been identified as threatened or endangered under the federal Endangered Species Act, or as species of special concern by the Alaska Department of Fish and Game (ADF&G). The Cook Inlet region includes many areas established by state or federal law to protect and preserve natural and critical habitats, wildlife populations, and to maintain public uses of these resources. Many of the region's special areas have legislatively defined restrictions on development activities.

## C. Current Uses

The Augustine Island area is currently primarily used and managed for research and education, and secondarily for commercial and subsistence harvest activities.

Research monitoring of the volcano has continued since the early 1980s without significant damage to property or loss of human life. The University of Alaska Fairbanks holds a State of Alaska Interagency Land Management Agreement (ILMA) with an ongoing development plan to monitor and record volcano activity. The seismic stations and monitoring equipment on Augustine Island provide warning signs of eruptions, ash hazards, other hazardous volcanic phenomena, and protect the safety and economic well-being of the state.

## D. Geothermal Resources on Augustine Island

Geothermal energy is heat that originates within the earth. Motion of the earth's crustal plates, uplifting of mountain ranges, occurrence of earthquakes, eruption of volcanoes, and spouting of geysers may generate or transport geothermal energy. Geothermal energy potential of the disposal area is indicated by the presence of Augustine Volcano. Subsurface and geologic data related to the geothermal resource potential of Augustine Volcano are not yet available. The Alaska Volcano Observatory (AVO) has published field studies conducted on Augustine Island related to the geohazards and volcanology of Augustine Volcano.

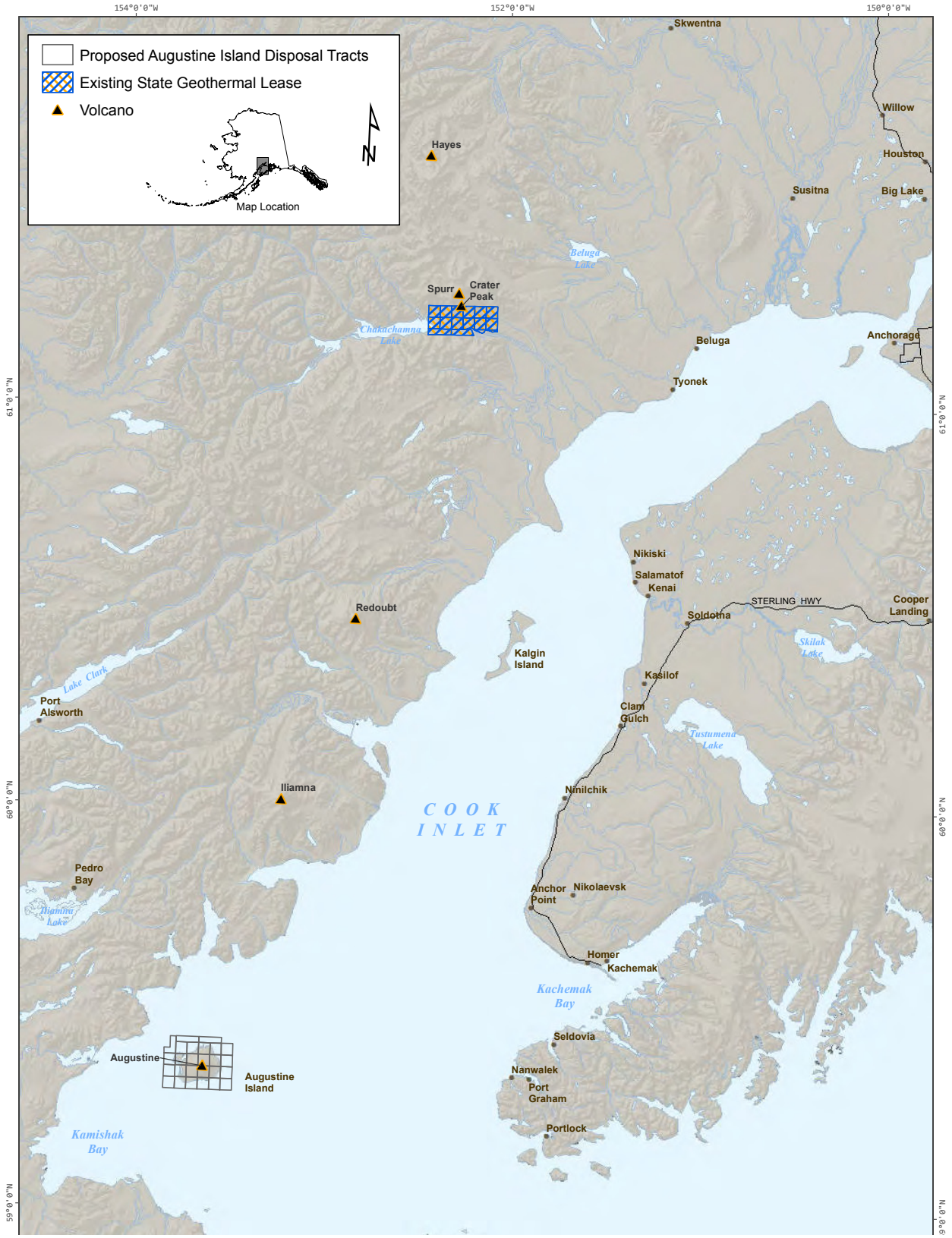


**Figure 1.1. Location of Augustine Island.**

## E. Reasonably Foreseeable, Significant Effects of Geothermal Resources Disposal

The reasonably foreseeable, significant effects of geothermal resources disposal on Augustine Island can be both positive and negative. Potential positive effects may be development of renewable energy sources for Alaska industries and residents.

Leasing activities alone are not expected to have any effects, other than initial revenue to the state. Post permitting and leasing activities could affect the terrestrial, freshwater, and marine habitats, and wildlife, birds, and fish of the disposal area and the uses of these resources. These activities may 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. Unintended occurrences such as hazardous substance spills could also have effects.

Potential effects of land disturbance and construction activities may alter habitats and impact the fish and wildlife that use them. During geothermal exploration, development, and production, subsurface engineering practices could result in induced land subsidence or induced seismicity.

Bird habitat disturbance and loss can cause impacts that affect nesting, foraging, brood rearing and molting. Well blowouts, oil or hazardous material spills can impact the immediate area with airborne contaminants, noise, heat stress, hazardous chemicals, wastes and the potential of ionizing radiation. Most potentially negative effects on habitats, birds, fish and marine mammal species, and their uses, and on local communities and residents can be avoided, minimized, or mitigated.

Releases of drilling muds, produced water, and solid waste discharges from exploration, development, and production activities could affect habitats on and around the island. Discharges of geothermal wastes or fluids into aquatic habitats may have a negative effect on the habitat quality, and are regulated by federal and state regulations to prevent negative impacts.

Geothermal development and production activities may produce emissions that have the potential to affect air quality. Gases and steam vapors can be emitted to the air from power generation, well testing, leakage of volatile petroleum components, supply activities and transportation vehicles. Administration of federal and state air quality statutes and regulations can avoid, minimize, and mitigate potential effects.

The potential future impacts to the historic and cultural resources at this location may be linked to accidental oil spills, erosion and vandalism. The state Office of History and Archaeology requires that any cultural resources be reported to their office. State and federal statutes and regulations are intended to mitigate effects to archaeological resources.

The island is the site of volcano and seismic research. The impacts to research equipment, facilities, and efforts will depend on the proposed projects and the volcano’s activity.

## F. Fiscal Effects

The potential development of geothermal resources for electric power generation and direct heating in the Cook Inlet region can increase both revenue from royalties and the additional benefits of power generation. Geothermally-generated electricity and subsequent growth

of geothermal-related infrastructure can help grow and sustain healthy economies for local communities and industries. Geothermal development on Augustine Island could also help satisfy the increasing demand for electricity and energy sources in Southcentral Alaska, and potentially reduce energy costs.

## G. Mitigation Measures

Mitigation measures address facilities and operations, reduction of impacts to habitats, fish and wildlife, subsistence and commercial harvest activities, management of fuels, hazardous substances, wastes, access, historical and cultural resources, and local hire, communications, and training. Specific measures are intended to protect terrestrial, freshwater and marine habitats, the fish, birds and wildlife that use them, and the island's air and water quality. Measures also require oil and hazardous substance spill prevention and control. However, mitigation measures cannot protect from all actions of a live volcano. Lessee advisories alert lessees to additional obligations and restrictions that government entities other than DO&G may impose on the lessee. The advisories are not intended to be exhaustive or as commentary on the jurisdiction of any government entity or propriety of any code, statute, or regulation. It is the lessee's responsibility to obtain all necessary state, federal, and local authorizations or permits relating to lease activities.

## H. Director's Written Finding

11 AAC 84.700(b) requires that before disposal of geothermal resources, the Director must determine whether the disposal is in the best interest of the state. After an appropriate review, the Director determined that approving Augustine Island geothermal resources disposal is in the best interest of the state. In making his 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 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 (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)).

In making this finding, the Director considered the disposal area, including its terrestrial, freshwater and marine 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 also considered public comments received, in a timely manner, during the calls for applications and comments.

The Director limited the scope of this finding to an administrative review of the applicable statutes and regulations and the facts and issues about the land that are known to him and are material to his decision. The type, location, duration, timing, or level of any exploration or development activities that may subsequently occur cannot be precisely determined at this time. Therefore, the Director did not speculate about the possible specific effects of future exploration, development, and production activities resulting from the disposal. The effects of future exploration, development, and production may be considered more specifically in the future, when government agencies and the public review permit applications for specific activities proposed at specific locations in the area. However, the Director did consider, in as

much detail as possible at this point, the potential effects that may occur subsequent to leasing and permitting.

Although the initial benefit to the state is the primary effect of exploration and leasing, the Director recognizes that geothermal exploration, development, and production subsequent to leasing may result in impacts to and around the disposal 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, commercial and subsistence harvest activities, management of fuels, hazardous substances, wastes, access, historical and cultural resources, and local hire, communications, and training.

Lessees must comply with all applicable local, state, and federal codes, statutes, and regulations. Lessee advisories notify lessees of other regulatory requirements, including those administered by: ADEC, ADF&G, AOGCC, OHA, ADNR, ADMLW, USCOE, USFWS, and KPB. 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; the lease contracts; 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 research, fishing, subsistence, and other concurrent uses.

The Director also weighed the potential positive effects to the state, and has concluded that developing the state's geothermal resources is vital to the economies of the state and Cook Inlet area communities and municipalities, and to the well-being of its citizens. Developing alternative energy sources, including geothermal resources, will also complement the state's energy portfolio goals.

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 concludes that the potential benefits of the disposal outweigh the possible negative effects, and that the approval for Augustine Island geothermal resources disposal will best serve the interests of the state of Alaska.

A person affected by this decision who provided timely written comments may request reconsideration, in accordance with 11 AAC 02. Any reconsideration request must be received by the 20th day of issuance, and may be mailed or delivered to:

Daniel S. Sullivan, Commissioner
Alaska Department of Natural Resources
550 W. 7th Avenue, Suite 1400
Anchorage, Alaska 99501

By fax to: 1-907-269-8918

By email: dnr.appeals@alaska.gov

If reconsideration is not requested by that date or if the commissioner does not order reconsideration on his own motion, this decision goes into effect as a final order and decision on the 31st day after the date of issuance. Failure of the commissioner to act on a request for reconsideration within 30 days after issuance of this decision is a denial of reconsideration and

is a final administrative order and decision for purposes of an appeal to Superior Court. The decision may then be appealed to Superior Court within a further 30 days in accordance with the rules of the court, and to the extent permitted by applicable law. An eligible person must first request reconsideration of this decision in accordance with 11 AAC 02 before appealing this decision to Superior Court. A copy of 11 AAC 02 may be obtained from any regional information office of the Department of Natural Resources.

January 14, 2013

W. C. Barron, Director
Division of Oil and Gas

Date

January 14, 2013

Daniel S. Sullivan, Commissioner
Department of Natural Resources

Date

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# Chapter Two
# Introduction

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 Alaska Department of Natural Resources (ADNR) 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 over activities resulting from resources exploration, development, and production.

## A. Process

Alaska statutes govern the disposal of state-owned mineral estate interests. Under AS 38.05.035(e), the ADNR 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.

The DO&G began the process of developing a finding by issuing a call for applications and comments for the proposed Augustine Island geothermal resources disposal on April 9, 2007. The DO&G received two applications from this effort, and comments from agencies and the public. The DO&G issued an additional request on April 17, 2009, for information from government resource agencies, local governments, and Alaska Native corporations. Comments received in a timely manner were considered for this finding. See Appendix A for a summary of the comments received and the ADNR response to each.

After consideration of the facts, laws, comments, and issues before him, the director made a determination and developed this written finding. This written finding:

- establishes the scope of the administrative review,
- addresses the reasonably foreseeable, significant effects of the uses proposed by the disposal,
- limits the scope to a review of applicable statutes and regulations, facts, and issues the director finds are material to the determination that the Augustine Island geothermal resources disposal serves the state's best interests (AS 38.05.035 (e)(1)(A)&(B), and
- discusses material issues that were raised during the public comment periods.

The DO&G may issue a "lease" to a "lessee" or a "prospecting permit" to a "permittee". For simplicity's sake, this written finding will use the term "lessee" to apply to the "lessee" or "permittee".

## B. Scope of Administrative Review

In the written finding, the director establishes the scope of the administrative review on which the director's determination is based. 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)).

The Director interprets "reasonably foreseeable" to mean there must be:

- some cause/result connection between the proposed disposal and the effect to be evaluated;
- a reasonable probability that the effect will occur as a result of the disposal; and,
- the effect will occur within a predictable time after the disposal.

Therefore, this finding does not speculate about potential but improbable future effects, but instead reviews only reasonably foreseeable effects of the proposed disposal. A reasonably foreseeable effect must also be "significant." The Director interprets "significant" to mean 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 disposal, and issues that the director finds are material to the determination of whether the proposed disposal will best serve the interests of the state.

# Chapter Three
# Description of the Disposal Area

Geothermal resources in the Cook Inlet area are associated with the Alaska Peninsula and Aleutian Islands volcano chains. Geothermal resource distribution throughout Alaska is located across southeast Alaska, the Interior, and the Aleutians (AEA 2009). The Alaska Energy Authority rates the state as commercially ready to implement technology. The abundant cold water resources encourage potential for small scale electrical power generation (AEA 2009). If geothermal temperatures are greater than 350° F, conventional steam turbine plants can be used. When temperatures are less than 350° F, a binary power generation system is more favorable (AEA 2009).

## A. Property Description

Augustine Island is located near Kamishak Bay on the west side of Lower Cook Inlet, approximately 60 miles southwest of Homer and approximately 180 miles southwest of Anchorage. West of Augustine Island are the Chigmit and Alaska-Aleutian mountain ranges. The Chugach Mountains are located to the east. Augustine Island is formed by numerous eruptions of Augustine Volcano from which debris avalanches and lahars have deposited sediment on the flanks of the volcanic cone and in the surrounding waters.

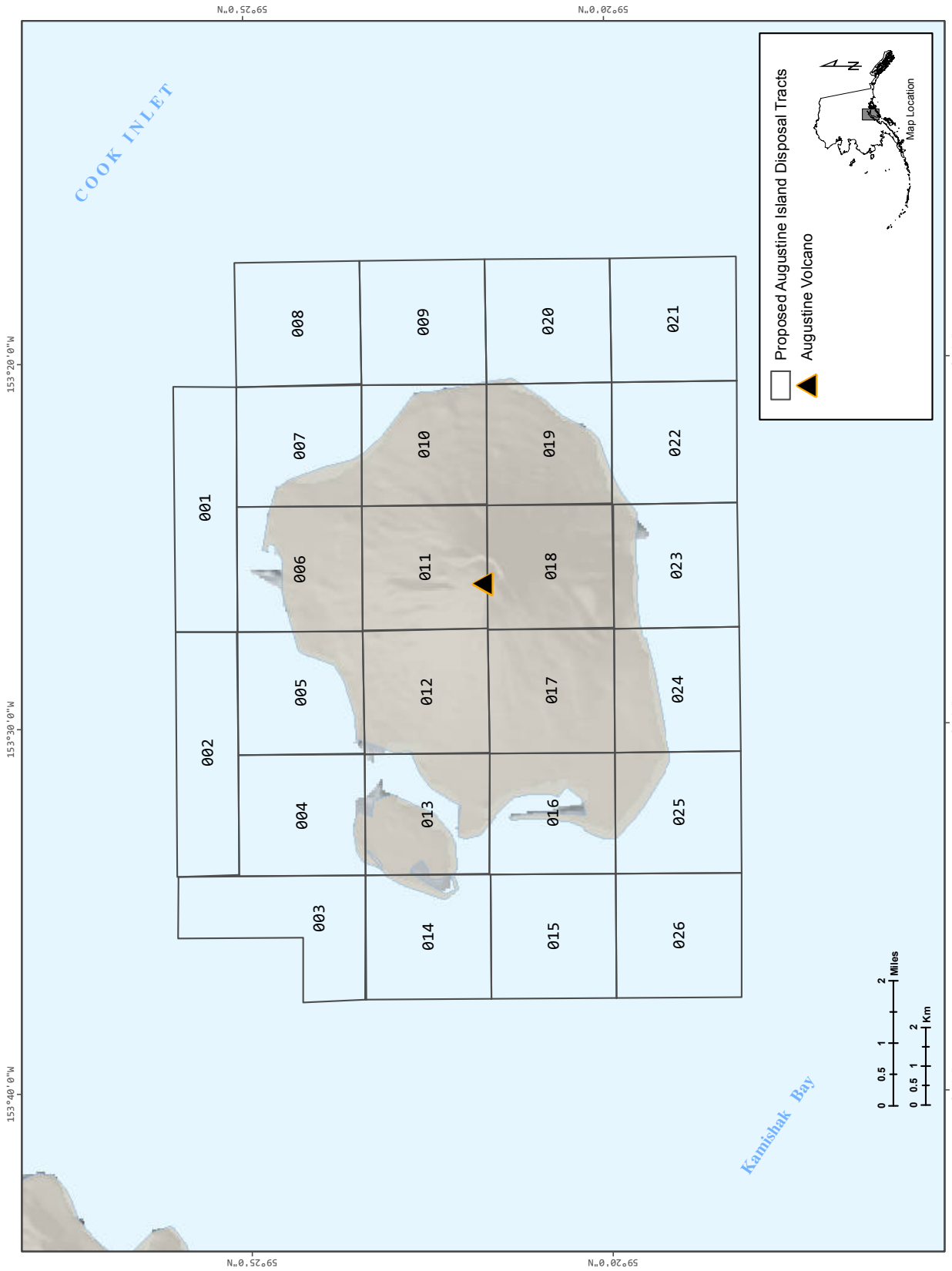
The Augustine Island geothermal disposal area (Figure 3.1) consists of the entire Augustine Island, including some tidelands and adjacent waters within approximately 3 miles of the island, and excludes nearshore tidelands of the mainland to the west. The area contains about 65,992 acres divided into 26 tracts, ranging from 2,489 to 2,560 acres. The state owns the land within the proposed disposal area, and Augustine Island is entirely located within the Kenai Peninsula Borough (KPB).

## B. Cultural and Historical Background and Resources

At the time of first European contact, Dena'ina Indians occupied the Cook Inlet area. These nomadic bands came to the region about AD 500 to 1,000 (CIRI 2011). Evidence from the Yukon Island site in Kachemak Bay shows that Lower Cook Inlet was occupied by Eskimos from about 1500 BC to 1000 AD and then later by Athabaskan Indians (Selkregg 1975). Although historical subsistence hunting and gathering has occurred near Augustine Island, there are no records of settlements on the island aside from a remote, abandoned cabin likely used by miners during a brief period of pumice mining on the island in the late 1940s and early 1950s. No historic or prehistoric sites are reported within the proposed disposal area (Dale 2010).

## C. Geologic Hazards

Augustine Volcano is an active volcano in the Cook Inlet region and presents several potential geologic hazards to the island and surrounding waters (Waitt et al. 1996). Hazardous phenomena recorded at Augustine Island include volcanic ash clouds, ash fallout and volcanic bombs, pyroclastic flows, debris avalanches, tsunamis, earthquakes, directed blasts, lahars and floods, volcanic gases, and lava flow (Waythomas and Waitt 1998). Augustine Volcano has experienced major eruptions since 1883, such as eruptions in 1935, 1963-64, 1976, 1986, and December 2005 through 2006 (Nye 2007). In early 2006, eruptive events included explosive ash, pyroclastic flow eruptions, and lava dome eruptions (Beget and Kowalik 2006). By mid-2006, avalanche events and pyroclastic flows decreased with the exception of a minor spike in such events during April, in which several rock falls and avalanches contributed to the




**Map 3.1. Proposed Augustine Island lease sale tracts.**

formation of an ash blanket on the southwest flank of Augustine Volcano (Waythomas and Waitt 1998).

## 1. Volcanic Ash Clouds, Ash Fallout, and Volcanic Bombs

Historically, Augustine Volcano has explosively erupted, sometimes ejecting very large fragments of magma thousands of feet into the atmosphere. Larger-sized volcanic debris, called blocks or bombs, typically strike near the vent of the volcano. Microscopic ash or tephra ejected from the volcano form ash clouds which may drift in the wind for several weeks or days, and pose potential threats to air travel. The Alaska Volcano Observatory (AVO) reported that ash clouds from the 1976 and 1986 eruptions reached altitudes higher than 12,000 m. In 1976, five jet liners experienced severe abrasion on exterior parts of the aircraft, but no crashes resulted from the ash cloud encounters. In March 1986, a DC-10 aircraft encountered an Augustine Volcano ash cloud during descent into the Anchorage airport, but landed safely, and air traffic was routed around the ash cloud for several days (Waythomas and Waitt 1998).

J Adleman AVO/USGS

Eastern flank of Augustine Volcano

Ashfall occurs when clouds of ash accumulate and fall to the earth as they drift away from the volcano. Depending on the extent or thickness of the ashfall, infrastructure may collapse under the added weight of ash. Public health is a concern during periods of ashfall. Visability may be significantly decreased and inhaling volcanic ash can cause respiratory issues (Waythomas and Waitt 1998).

## 2. Pyroclastic Flows and Debris Avalanches

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 2004). The cone of Augustine Volcano has been built up vertically over the last two thousand years causing about a dozen major avalanches, and creating areas of hummocky topography on Augustine Island and irregular bathymetry in nearshore waters (Waythomas and Waitt 1998; Nye 2007).

A debris avalanche is the rapid downslope movement of rock, volcanic debris, snow, ice, or other pyroclastic materials. Debris avalanches are not always associated with eruptive

events; heavy rainfall, the intrusion of magma, or earthquakes can also cause catastrophic avalanches (USGS 2007). Pyroclastic flows and debris avalanches can move at speeds of three to six miles per second, creating a serious hazard to life and property on the island (Waythomas and Waitt 1998). An eruption in 1976 caused a pyroclastic flow which damaged AVO infrastructure and equipment on the north shore of the island (Nye 2007).

Pyroclastic flows and debris avalanches moving rapidly down the volcano flank can extend beyond tidelands, potentially generating tsunamis (Waythomas and Waitt 1998; Nye 2007). The topography of Augustine Island would cause a pyroclastic flow to spread out laterally from the vent, although it is unlikely that a flow would reach more than three miles off the island's shore (Waythomas and Waitt 1998).

M.E. Yount, AVO/USGS

Pyroclastic flow on north flank of Augustine Volcano, March 30, 1986

## 3. Tsunamis

A tsunami could be generated if large amounts of volcanic debris were to rapidly enter the surrounding waters during a large eruption of Augustine Volcano (Waythomas and Waitt 1998). Several historical eruptions have initiated small volume pyroclastic flows which reached the surrounding waters. However, only the 1883 eruption appears to have caused a debris avalanche which initiated a tsunami observed at English Bay, at the location of modern day Nanwalek and Port Graham (Waythomas and Waitt 1998). The 1883 tsunami resulted in flooding of coastal homes and kayaks being washed away, yet no fatalities were reported (Beget and Kowalik 2006). There is potential for a large avalanche of debris to flow into Lower Cook Inlet and create a radiating tsunami (Waitt 2006).

Tsunami magnitude is based on several factors: the volume and velocity of debris entering the sea, water depth in the runout zone, and the position of tides during the eruption (Waythomas and Waitt 1998). Low-lying areas along the coastline of Lower Cook Inlet would be the most susceptible to a tsunami, especially if an eruptive event occurred during high tide (Waythomas and Waitt 1998). However, it is difficult to assess the tsunami hazard at Augustine Island because of the lack of geologic evidence and eye witness accounts (Waythomas and Waitt 1998).

## 4. Earthquakes

The Augustine Island area is vulnerable to naturally occurring subduction zone earthquakes caused by one geologic crustal plate moving beneath another. In Southcentral Alaska, the oceanic Pacific Plate is slowly subducting, or moving beneath the North American continental plate. Volcanoes, such as Augustine Island and those located on the Aleutian Islands, are usually associated with this type of tectonic plate convergence. Earthquakes can cause landslides, avalanches, tsunamis, uplift, subsidence, infrastructure failures, and soil liquefaction (DHSEM 2007).

## 5. Directed Blasts

A directed blast is a large explosion which can occur if a volcano's internal vent system becomes compromised or uncapped. Directed blasts of Augustine Volcano are rare; there is evidence of only one directed blast occurring in the last 400 years (Waythomas and Waitt 1998). A directed blast on Augustine Island would happen quickly, leaving little or no time for evacuation, and would destroy anything in the immediate vicinity by impact, burial, and intense heat (Waythomas and Waitt 1998).

## 6. Lahars and Floods

Various types of flowage phenomena can occur on Augustine Island as a result of pyroclastic flows and eruptive events. When in contact with hot, volcanic material, snow and ice on the flanks of the volcanic cone will melt and move rapidly downslope in the form of lahars and floods (Waythomas and Waitt 1998). Lahars may contain large boulders, sand, or silt, and travel quite quickly, or they may subside into smaller flooding events (Waythomas and Waitt 1998). Both lahars and floods pose a serious risk to the entire island, although it is unlikely either would reach much further than near shore areas (Waythomas and Waitt 1998).

## 7. Volcanic Gases

Gases may be emitted by active volcanoes during periods of unrest or eruptive events. Common gases emitted by Augustine Volcano are water vapor, carbon dioxide, carbon monoxide, sulfur dioxide, and hydrogen sulfide (Waythomas and Waitt 1998). When dispersed by the wind, gases can displace oxygen, cause acid precipitation, and may cause skin and respiratory irritation. The hazards from volcanic gases at Augustine Island are minor and may only pose a threat to those directly in the vicinity of the cone (Waythomas and Waitt 1998).

## 8. Lava Flow

Lava flows develop after explosive activity, yet narrow streams of molten rock or lava have formed only rarely at Augustine Volcano. Most Augustine flows are andesitic in composition and tend to move more slowly. However, as lava flows develop they may cause secondary events, such as a debris avalanche (Waythomas and Waitt 1998).

G. McGimsey, AVO/USGS

Lava flow on northeast side of Augustine Volcano

## 9. Geohazards Related to Geothermal Resource Activities

The temperature and geochemistry of geothermal dry steam and liquid resources can cause potential hazards to humans, wildlife, birds and fish during resource exploration and development activities. Hydrogen sulfide can occur naturally, and toxic exposure to this compound can cause injury or death (OSHA 2011). The high temperatures of the geothermal resource can also cause potential hazards upon direct contact (OSHA 2011). The production of geothermal energy has caused some evidence of ground subsidence and induced seismic activity.

## D. Mitigation Measures

Several geologic hazards exist in the proposed Augustine Island geothermal disposal area that could pose potential risks to geothermal exploration, development, or transportation, both onshore and offshore. As discussed above, the potential natural hazards include volcanic ash clouds, ash fallout and volcanic bombs, pyroclastic flows and surges, debris avalanches, landslides and subsidence, tsunamis, earthquakes, directed blasts, lahars and floods, pumice rafts, volcanic gases, and lava flow. Geothermal resource infrastructure does not currently exist in the Lower Cook Inlet area.

Measures in this written finding, along with laws imposed by state, federal, and local agencies are expected to minimize or mitigate some potential hazards. However, geothermal resources exploration, development, production, and transportation on an active volcano involve risk. Lessees will assume all risk for their activities on the island. A complete list of mitigation measures is found in Chapter Eight.

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# Chapter Four
# Habitat, Fish, and Wildlife

The Augustine Island geothermal resources disposal area contains a variety of habitats that support several fish and wildlife species.

## A. Major Habitats of the Disposal Area

### 1. Terrestrial Habitats

The terrestrial land forms of Augustine Island support moist tundra, with brush vegetation on lowlands on the flanks of the volcano (ADF&G 2006). During periods of volcanic inactivity, vegetation and soil development may occur on the island. Aerial photography and GIS mapping show some areas of vegetation extending from the base of the volcanic cone to the shoreline. The limited terrestrial vegetation is not sufficient to support large mammals. There is currently no information available to indicate that large mammals inhabit the terrestrial habitats of Augustine Island.

K. Bull AVP/USGS

Terrestrial habitat of Augustine Island

The terrestrial environment on Augustine Island consists of low shrub communities of willow, birch, and alder, interspersed with lichen and grass communities. The relatively thin soils of upland areas support communities of heath tundra and sedges. However, most upland areas are barren, rocky, and lacking in vegetation. Ericaceous species such as mountain cranberry, bog blueberry, and crowberry are present, and stunted trees may exist in sheltered areas (ADF&G 2006).

Much of the island below the volcanic cone consists of wetlands and shallow marine habitats, such as freshwater and saltwater marshes. Waterfowl and seabirds use shallow marine habitats such as lagoons, bays and wetlands as staging and overwintering areas (ADF&G 2006). High cliffs, wave beaten platforms, and boulder beaches ring the island, providing rookeries and haulouts for Steller sea lions, harbor seals, and sea otters (ADF&G

2006). The National Marine Fisheries Service (NMFS) has not designated important rookeries or haulouts for these marine mammals on Augustine Island.

Numerous wetlands, such as grass and sedge, as well as salt marshes, exist along the coastline of Augustine Island. Grass wetlands consist mainly of water tolerant grass species often intermixed with sedges and aquatic mosses (ADF&G 2006). This habitat is important for recharging ground water and containing flood or storm waters (ADF&G 2006).

Sedge wetlands exist in very wet areas of floodplains and in depressions of upland areas. Water-tolerant plants such as tall sedges, cotton-grasses, rushes, and on occasion, aquatic mosses, are abundant in these habitats (ADF&G 2006).

Salt marsh habitats are intertidal wetlands composed of salt tolerant plants and are typically located on tide flats, behind barrier islands, coves, and spits (ADF&G 2006). Salt marsh wetlands provide spawning and nursery habitat for many marine organisms, such as crab and Pacific herring (ADF&G 2006). A variety of waterfowl, shorebirds, and small mammals use salt marshes as areas of rest and refuge (ADF&G 2006).

## 2. Marine Habitats

The marine habitats of the disposal area extend from the shoreline of Augustine Island to 3 miles offshore, excluding nearshore/mainland tidelands that fall outside of the geothermal resources disposal area. The Augustine Island coastline has rocky headlands and secluded sandy coves, and a long spit that forms the southwest part of the island. Habitat types include rocky intertidal areas, mudflats and beaches, eelgrass beds, and nearshore, benthic environments. The rocky beach deposits mainly consist of cobbles and boulders, as well as gravel, sand deposits, and exotic pebbles. Erosion of sea cliffs and new sediment contributions to beaches occur largely during extreme winter storms (Waitt et al. 1996). Marine habitats of the area are important to several species of seabirds and shorebirds, fish, sea mammals, and other aquatic organisms.


AVO/USGS

Marine habitats along Augustine Island coastline

Intertidal areas surrounding the island extend from the water's reach at highest tide to the water's reach at lowest tide, and support a variety of aquatic organisms, plants, and other animals (Field and Field 1999). Three habitat types within the intertidal zone include: rocky intertidal areas; mudflats and beaches; and eelgrass beds (ADF&G 2006).

Rocky intertidal habitats on Augustine Island consist of exposed, rocky shores that experience high to moderate wave activity and sheltered, rocky shores found along the inside of bays and coves (ADF&G 2006). Cracks, crevices and rock bottoms provide shelter

for mussels and other organisms from predators and wave action. Soft-bottom substrates provide space for burrowing organisms (ADF&G 2006). Red and brown algaes, as well as kelps and rockweed, dominate the floral community within rocky intertidal habitats (Field and Field 1999).

Mudflats and beaches are characterized by unconsolidated substrate habitats ranging from fine-grained sand to mixed sand and gravel beaches, and exposed and sheltered tidal flats (ADF&G 2006). The different types of substrates each support a distinct biological community, including clams, amphipods, and other invertebrates. Mudflats are an important stopover location for migrating birds, and provide haulout areas for harbor seals (ADF&G 2006).

Dense clusters of eelgrass can be found in low intertidal and shallow mudflats areas (ADF&G 2006). They provide substrate and protection for a wide diversity of marine life. Eelgrass is susceptible to changes in turbidity and water quality, and the depth to which it grows is limited by the amount of light it receives (ADF&G 2006). The north and west shores of the island support eelgrass beds that are important anchorage sites for the commercial fishing fleet (Talbot 2007).

## 3. Fish and Wildlife Populations

The unique physical characteristics of the Augustine Island area support diverse habitats with a rich wildlife assemblage. Abundant forage fish provide ample food supplies for the seabirds and marine mammals of nearby habitats. Most populations of fish and wildlife are healthy, but a few have been identified as threatened or endangered under the federal Endangered Species Act (ESA) or as a Species of Special Concern (ASSC) by the ADF&G (Table 4.1).

**Table 4.1. Wildlife populations of Cook Inlet identified as threatened or endangered under the federal Endangered Species Act, or as Species of Special Concern by the ADF&G.**

| Species | Status |
|---|---|
| Beluga whale (Cook Inlet stock) | Endangered, ASSC[a] |
| Harbor seal | ASSC[a] |
| Northern sea otter | Threatened, ASSC[a] |
| Spectacled eider | Threatened |
| Steller's eider (Alaska breeding population) | Threatened, ASSC[a] |
| Steller sea lion (west of 144° longitude) | Endangered, ASSC[a] |
| Steller sea lion (east of 144° longitude) | Threatened, ASSC[a] |

[a] = Alaska Species of Special Concern (ASSC) (2009).

### *a. Fish and Shellfish*

Five species of Pacific salmon are found in the surrounding waters of the Augustine Island area: Chinook, sockeye, coho, pink, and chum. During the spring, juvenile salmon migrate through nearshore waters surrounding Augustine Island, and in the summer adult salmon migrate near the island to reach freshwater streams in Cook Inlet (Maclean 2007).

No anadromous fish streams, rivers, or lakes occur on Augustine Island (Johnson and Klein 2009). Forage fishes in the Augustine Island area include Pacific herring, Pacific cod, Pacific halibut, walleye pollock, arrowtooth flounder, and shellfish (NOAA 2009).

#### *b. Birds*

Waterfowl of the Augustine Island area include geese, swans, ducks, cranes and eiders. Lower Cook Inlet, including the disposal area, is an important stop-over site in the Gulf of Alaska for waterbirds migrating between wintering areas and breeding grounds (Witten 2003).

Many species of seabirds live in the Cook Inlet area, including murres, gulls, kittiwakes, cormorants, murrelets, and puffins. Lower Cook Inlet is one of the most productive areas for seabirds in Alaska; In July 1992, 2.2 million seabirds were documented to be foraging in the area (Piatt 1994).

The Cook Inlet area is also an important wintering area for many shorebird species, including rock sandpipers, migrating western sandpipers and dunlin, and for breeding and migrating Hudsonian godwits, greater yellowlegs, solitary sandpipers, and short-billed dowitchers (ADF&G 2007; Gill and Tibbitts 1999). Mudflats in the Augustine Island area provide important alternate foraging habitat in the winter for sandpipers.

### 4. Marine Mammals

Marine mammals of the Augustine Island disposal area include beluga whale, sea otter, Steller sea lion, harbor porpoise, and harbor seal. Some species have been identified as threatened or endangered under the federal ESA, or as ASSC by the ADF&G (Table 4.1). All marine mammals are protected under the Marine Mammal Protection Act (MMPA), under the authority of the National Oceanic Atmospheric Administration (NOAA) and NMFS. NOAA designated beluga whale critical habitat area including waters along the coastline of Kamishak Bay, located west of the shores of Augustine Island (NOAA 2011).

The US Department of the Interior designated critical habitat for the Southwest Alaska Distinct Population Segment of the northern sea otter including waters surrounding Augustine Island (USDOI 2009). Steller sea lions are listed as a threatened species under the ESA and critical habitat has been designated. However, critical habitat is not located within the disposal area.

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# Chapter Five

# Current Uses of the Augustine Island Area

The waters surrounding Augustine Island provide habitat for a variety of marine wildlife and fish species of interest. The unique geology and geographic location of Augustine Island offer opportunities for scientific research and monitoring of volcanic activity in Cook Inlet. The current uses of the disposal area are for research and education. The area is also used for commercial and subsistence harvest activities. 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 the University of Alaska, conduct research in Cook Inlet. Marine mammals and habitats, sea ice modeling, volcanics, and the health of fisheries are some of the many topics of research in this region (NOAA 2011; UAF 2011; AVO 2011; ADF&G 2010a; Marine Ecosystem Dynamics Modeling 2011).

The University of Alaska, Fairbanks (UAF) has been studying Augustine Volcano since the early 1970s. Since 1988, volcanic monitoring and research has been conducted through a cooperative effort of the Alaska Volcano Observatory (AVO), the U.S. Geological Survey (USGS), the University of Alaska Geophysical Institute, and the State of Alaska Division of Geological and Geophysical Surveys. The state determined that an Interagency Land Management Assignment (ILMA) would be more appropriate and in the best interests of the state, and issued an ILMA to UAF on May 26, 1992; ADL 225681 (DMLW 2011).

The seismic stations and monitoring equipment on Augustine Island provide warning signs of eruptions, ash hazards, other hazardous volcanic phenomena, and protect the safety and economic well-being of the state. The ILMA only grants UAF the authority to "access" all of the island that is in state ownership, and in no way restricts other state or public access. The current ILMA is valid through September 19, 2025 (DMLW 2011). Agencies that access the island to conduct research include AVO, USFWS, ADF&G, UNAVCO Plate Boundary Observatory, and AVO affiliates.

UAF and AVO operate several volcano monitoring instruments and equipment on Augustine Island and in the surrounding region. Eight permanent seismic and GPS stations exist on the island, although the total number of stations may fluctuate depending on the level of volcanic activity (Nye 2007). The purpose of these stations is primarily safety and hazard mitigation, such as warning of impending eruptions. Research of volcanic processes is a secondary goal. The total size of each station is about 100 square feet, with a majority of the equipment contained in a 4x4x5 ft fiberglass hut. Most stations consist of the instrument itself, a power system, and a radio-frequency telemetry system (Nye 2007).

## B. Fish and Wildlife Uses and Value

### 1. Commercial Fishing

A number of state commercial fisheries exist near and within a portion of the proposed Augustine Island geothermal exploration area. The vast fishery resources of Alaska are of tremendous importance to the history and culture of the area, and significantly contribute to the economy.

Cook Inlet is frequently divided into two main fisheries management areas: Upper Cook Inlet and Lower Cook Inlet. Augustine Island is in the Lower Cook Inlet management area, which includes Kachemak and Kamishak bays south to Cape Douglas and the Barren Islands. The Lower Cook Inlet Management Area has benefitted from fisheries enhancement for over three decades that has contributed up to 90 percent of the harvest (ADF&G 2011). All five species of Pacific salmon are commercially harvested in Cook Inlet, as well as weathervane scallops, and other species of groundfish and shellfish.

The most significant commercial fisheries in the Augustine Island area are salmon fisheries. Sockeye salmon are the most important economically, followed by pink, chum, coho, and chinook (Shields 2007; Table 5.1).

**Table 5.1. Commercial salmon catch and average salmon price in dollars per pound by species in Lower Cook Inlet, 2008-2010.**

| Year | Chinook | Sockeye | Coho | Pink | Chum | Total |
|---|---|---|---|---|---|---|
| **Harvest** | | | | | | |
| **2008** | 190 | 407,591 | 2,966 | 505,700 | 175,730 | 1,092,177 |
| **2009** | 84 | 280,312 | 2,686 | 989,347 | 73,974 | 1,346,403 |
| **2010** | 39 | 93,064 | 2,111 | 278,211 | 94,755 | 468,180 |
| **Price per pound** | | | | | | |
| **2008** | $3.42 | $1.45 | $0.76 | $0.23 | $0.55 | |
| **2009** | $3.45 | $1.55 | $0.83 | $0.22 | $0.53 | |
| **2010** | $3.57 | $1.95 | $1.05 | $0.33 | $0.79 | |

Source: Hammarstrom, L. and Ford, E. 2010. 2010 Lower Cook Inlet annual finfish management report. Division of Commercial Fisheries, ADF&G.

Shellfish species harvested commercially in the Augustine Island area include weathervane scallops, green sea urchins, and sea cucumbers.

## 2. Subsistence Fishing and Hunting

State and federal subsistence fishing for salmon occurs in Kamishak Bay near the Augustine Island area, and some hunting of marine mammals may occur in the area. Under Alaska law, subsistence is defined as “noncommercial, customary and traditional uses” of fish or game resources for a variety of purposes (ADF&G 2005). Most of the Cook Inlet area is designated as “nonsubsistence”. Alaska law AS 16.05.258 requires that subsistence uses be consistent with sustained yield.

The largest subsistence groups in the Lower Cook Inlet area nearest to the disposal area include residents of Kenai, Seldovia, Port Graham, and Nanwalek. Two scallop harvesting areas lie east of Augustine Island. Other shellfish harvested near the disposal area include Pacific razor clams, sea cucumbers, and sea urchins. Subsistence resources provide food supplies as well as materials for religious and social occasions (MMS 2003). Subsistence activities also provide an economic benefit to local harvesters such as the Cook Inlet Dena’ina, Kenaitze, Alutiiq, and Koniag, in addition to providing a sense of identity, the promotion of traditional family systems, and value of culture (MMS 2003).

The NMFS regulates subsistence hunting of belugas in Cook Inlet. It sets an annual harvest quota based on the abundance and growth of the population (NMFS 2008a). Harvests are authorized only when the five year average abundance is more than 350 whales.

Subsistence activities also occur onshore on the west side of Cook Inlet. The villages of Tyonek and Beluga are located north of Augustine Island in Upper Cook Inlet. Residents of these villages are active in subsistence hunting, fishing and gathering (Braund 2007). Use of the onshore areas west of Augustine Island for subsistence may occur, as well as seasonal subsistence activities on or near Augustine Island.

## 3. Sport Fishing and Hunting

Sport fishing is an important part of the culture and economy of the Cook Inlet area, providing recreation, food, and jobs to both residents and visitors. It is estimated that $733 million in spending by anglers in the Cook Inlet area in 2007 generated $171.5 million of income to 5,282 employees (Southwick Associates, Inc. et al 2008). Sport fishing in the disposal are is limited by access.

Sport hunting is also important to the culture and economy of the Cook Inlet area. Hunters harvest large and small mammals, furbearers, and waterfowl in the Cook Inlet area. However, hunting is limited in the disposal area due to lack of wildlife and access to the area.

## 4. Recreation and Tourism

The Cook Inlet area is well known for its recreational opportunities, and tourism is a vital component of most local economies. However, recreational use of  and tourism in the Augustine Island area is limited due to its remote location and the hazards associated with Augustine Volcano. There are no roads within the Augustine Island disposal area. Further, access is restricted to small aircraft or boat.

## 5. State Game Refuges, Critical Habitat Areas, and Other Designated Areas

Near the Augustine Island area is the Kamishak Special Use Area, Units 8, 9, 23, and 596 of Region 12 described in the Kenai Area Plan. It is managed by the Kenai Peninsula Borough. The designation recognizes the importance of the area for its remote character and fishery resources, both habitat and harvest (DMLW 2001). McNeil River State Game Sanctuary attracts the highest concentration of brown bears in the world, and is a popular wildlife viewing destination for visitors. The sanctuary is managed by the ADF&G, which limits the number of visitors to the sanctuary. The area is roadless and virtually undisturbed by human development. Access to McNeil River is only by floatplane (ADF&G 2010b).

Marine waters surrounding and within the vicinity of Augustine Island are designated as Essential Fish Habitat (EFH) for some marine species. EFH near or within the disposal area has been designated for weathervane scallops, arrowtooth flounder, Pacific cod, pollock, and all five species of Pacific salmon, as well as other marine species (NMFS 2008b). Katmai National Park and Preserve is well known for its scenic beauty and prominent salmon runs which attract large numbers of brown bears in the summer months. Sport fishing is renowned in many of the area's streams and lakes; anglers fish for sockeye and coho salmon, Dolly Varden, and rainbow trout. Access to the park is limited by small aircraft or boat (NPS 2008).

### 6. Oil and Gas Exploration and Development

Oil and gas exploration, development, and production have been ongoing in the Cook Inlet area since 1957. The oil and gas industry is an important employer in the area, and is critical to the area's economy. The residents of the region benefit from locally produced natural resources and energy.

The USGS estimates technically recoverable resources of 19 trillion cubic feet of natural gas, about 600 bbls of oil and about 46 million bbls of natural gas liquids in the Cook Inlet region (USGS 2011b). This study incorporates evaluation of both unconventional and conventional petroleum resources, and addresses technically recoverable oil and gas resources for onshore and offshore areas (USGS 2011). The DO&G estimates the Cook Inlet basin is capable of supplying regional natural gas needs through 2020 (ADNR 2011; ADNR 2009).

### 7. Renewable Energy

Several types of renewable energy sources including wind, tidal, and potentially viable geothermal energy resources in Cook Inlet are being explored (CIRI 2011; Ocean Energy Council 2011; Bradner 2011; Motyka et al. 1993). Geothermal resources in the Cook Inlet area are associated with the Alaska Peninsula and Aleutian Islands volcano chains (AEA 2007). The area is known for active volcanic formations along the Aleutian arc, and interfaces with geothermal systems (Motyka et al. 1993). The areas at and near Augustine Island present geothermal energy resource potential (REAP 2011; Motyka et al. 1993).

The potential uses of geothermal resources are for generation of electric power, direct heating of facilities, absorption chilling, greenhouses, process heating in the seafood industry, mariculture, swimming pool heating, and hydrogen production (AEA 2007).

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# Chapter Six

# Geothermal Resources in the Augustine Island Disposal Area

## A. Geology

The geology of Augustine Island is related to volcanic activity in the Cook Inlet region. Augustine Volcano is a cone-shaped stratovolcano (Waythomas and Waitt 1998). The volcanic cone and deposits form most of Augustine Island, a 5 by7 mile, circular shaped island situated in Kamishak Bay on the west side of Lower Cook Inlet.

At least 6 major eruptions have occurred in the past 200 years. The summit lava-dome of the 4,114 ft tall volcano has repeatedly collapsed over the centuries, depositing pyroclastic debris and ash on the flanks of the volcano and into the surrounding sea. The ongoing eruptions and debris avalanches, which occur about every 150 to 200 years, have shaped the irregular coastline of Augustine Island (Waythomas and Waitt 1998).

## B. Geothermal Energy Potential

Geothermal energy is the naturally occurring heat that originates within the earth. Alaska statutes define a geothermal resource as "the natural heat of the earth at temperatures greater than 120 degrees Celsius, or any use of that heat for commercial purposes, measured at the point where the highest temperature resources encountered enter or contact a well or other resource extraction device…" (AS 41.06.060(5)(A)). Geothermal energy may be in the form of hot water, hot dry steam, hot dry rock or any other geological material. The key aspect is that geothermal energy is an occurrence of heat within the earth. Based on the nature of the resource a portion of the concentrated heat can be captured for electricity production or direct heating (Austin 1986; USDOE 2011b).

Geothermal resources commonly coincide with areas of tectonic plate boundaries and recent geologic activities (University of Utah 2001). Tectonic activity allows magma or superheated groundwater to reach the earth's surface, creating areas of higher temperature resources at recoverable depths (Bronicki 2003). The large number of active volcanoes suggests there is significant heat in many areas in Alaska (Massachusetts Institute of Technology 2006). Geothermal resources in the Cook Inlet area are associated with the Alaska Peninsula and Aleutian Islands volcano chains (AEA 2007). The area at and near Augustine Island presents geothermal energy resource potential (REAP 2011; Motyka et al. 1993).

Geothermal energy potential of the disposal area is indicated by the presence of Augustine Volcano. Subsurface and geologic data related to the geothermal potential of Augustine Volcano are not yet available. The Alaska Volcano Observatory (AVO) has published a few studies conducted on Augustine Island, but these are related to the geohazards and volcanology of Augustine Volcano, rather than geothermal resources potential (Waythomas and Waitt 1998; Waythomas and Nye 2002).

## C. Geothermal Resource Development

Geothermal resources can be accessed by wells using the heat energy for generating electricity, or the heat can be used directly for uses such as heating buildings. Geothermal resources

must be near the surface and of very high temperature to be economically recoverable (BLM 2007; University of Utah 2001). The following section briefly describes the activities typically undertaken to explore, develop, and use geothermal energy resources. Actual development activities may vary depending on the conditions and exploration results.

## 1. Exploration

Geothermal resource exploration begins with locating the resource, and estimating the depth, volume, temperature, and accessibility of the resource. Remote sensing technologies can be used to detect different wavelengths of light to differentiate between different rock types (Jennejohn 2009). Next, the geophysics or chemical and physical nature of the resources is determined to estimate the placement of wells (Bronicki 2003). Other typical exploration activities include geologic mapping, geophysical surveys, gravity and magnetic surveys, seismic surveys, resistivity surveys, and temperature measurements. When a geothermal prospect is located, shallow holes (100 to 3,000 ft deep) are drilled to determine the temperature gradient of a geothermal system (BLM 2007). The drilling program may include temperature gradient wells, slim holes, and/or full-size exploration wells (Fleischmann 2010). Use of wireline logging tools can enhance data collection and subsequent analysis of the resource (Long et al. 2010).

Because geothermal resources are not always visible from the surface, the lessee must correctly measure and interpret geological and geophysical information in order to develop an appropriate drilling and well testing program (Geothermal Resources Council 1986). Drilling activities may also encounter hydrocarbons in some regions, and drilling programs must be designed to prevent blowouts and mitigate safety concerns (Finger and Blankenship 2010).

Geothermal drilling practices focus on entering “live” production zones to access heat via steam or brine fluids. These zones must possess acceptable characteristics for resource development, such as temperature, porosity, permeability, fracture networks, and must be economically feasible (Finger and Blankenship 2010).

New emerging technologies add additional criteria for feasible development and energy production. Enhanced Geothermal Systems (EGS) are emerging as potential solutions for problems with development of conventional geothermal systems. These technologies can increase the likelihood of success by increasing porosity, permeability, and can extend the lifecycle of the reservoir (Long et al. 2010).

By using thermal, hydraulic and chemical processes, reservoirs are fractured and interconnected for higher permeability. The result encourages geothermal heat to be conducted and accessed for development (USDOE 2005; USDOE 2011a). EGS advancements are showing better results and increased understanding relating to geothermal reservoir performance (Moore 2007). The location, reservoir management and economic feasibility components may influence both exploration and development drilling, and related land management practices (Finger and Blankenship 2010).

## 2. Development and Production

The results of the exploration information about depth, temperature, rock type, geofluids and heat transport mechanisms provide data for continued development efforts (Lowry et al. 2010). Evaluation of the feasibility and costs for heat extraction, heat conversion, well field

size, spatial constraints, regulatory permitting and institutional requirements, and economics drive development activities (Lowry et al. 2010).

After surface exploration and shallow drilling have identified potential geothermal resources, deep drilling and testing are necessary to determine the commercial viability of the resource. Most commercial geothermal systems consist of many wells spaced over a hydrothermal reservoir. The permeability and porosity of the host rock will determine the appropriate spacing of geothermal wells. Producing wells are connected to power plants through gathering lines (Geothermal Resources Council 1986).

Electrical generation from geothermal resources can be accomplished in several ways. The precise technology used for electricity generation depends on the temperature, pressure, and amounts of steam and water in the geothermal system, and is determined during the exploratory and development stages. Most geothermal electrical generating plants are of three types: dry steam; flashed steam; or binary cycle power generation (EERE 2011).

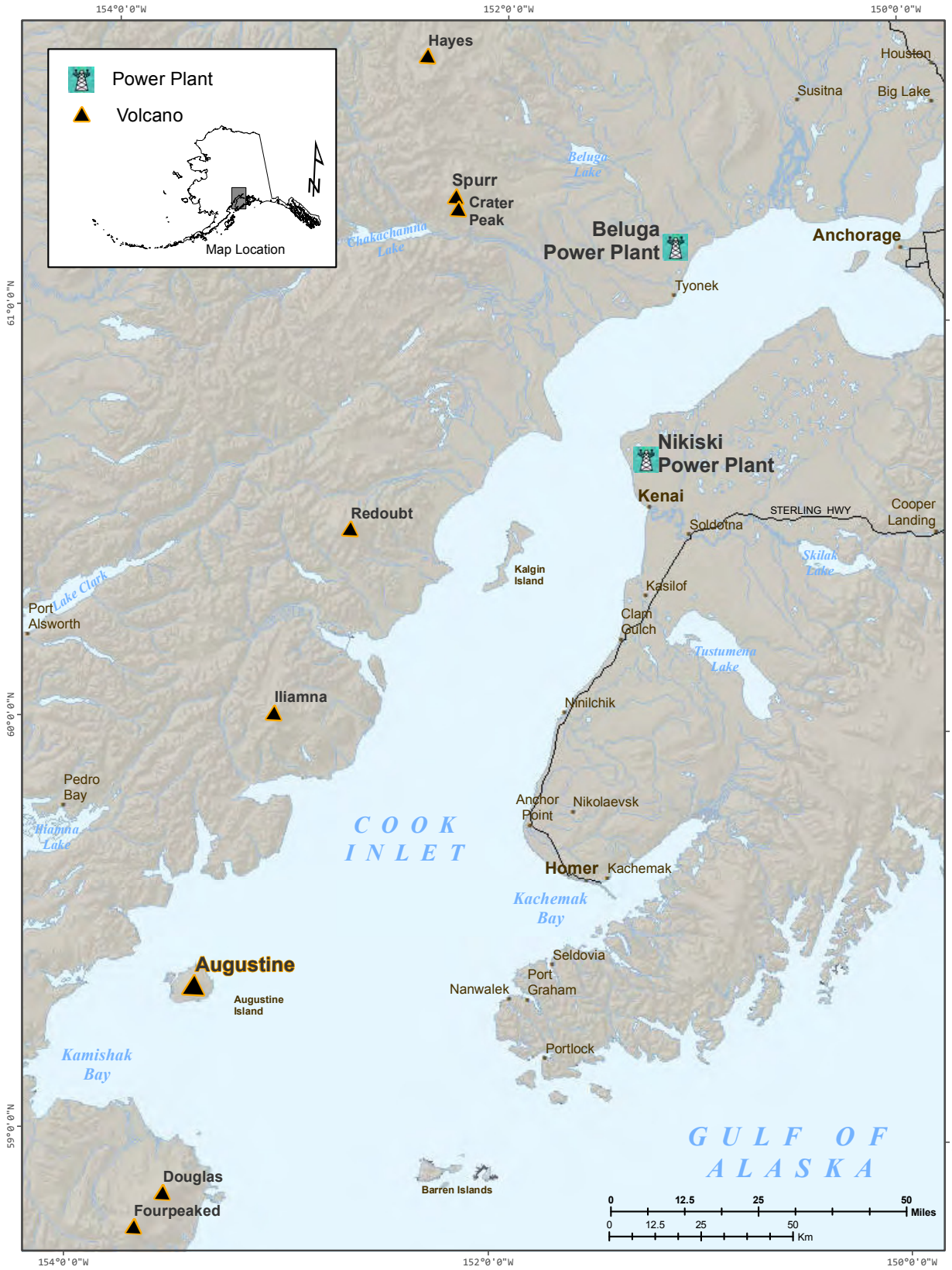
Geothermal resources discovered on Augustine Island may be converted to electric power using a binary cycle, flashed steam, dry-steam plant, or another method, depending on the temperature and other resource characteristics.

## 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). Augustine Island is in a remote location far from existing electrical power grid infrastructure. The two nearest power plants are the Beluga facility, operated by Chugach Electric Association, and the Nikiski generation plant, operated by Homer Electric Association (Map 6.1). The Beluga power plant is located on the west side of Upper Cook Inlet near Tyonek, approximately 150 miles northwest of Augustine Island. The Nikiski power plant is located in Nikiski, approximately 112 miles from Augustine Island.

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.




**Map 6.1. Power plants nearest to Augustine Island.**

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# Chapter Seven

# Reasonably Foreseeable, Significant Effects of Leasing, Exploration, and Subsequent Activity

Until the permit is issued, or subsequent geothermal leases are sold 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, lessee, operator, and discovery. The Director is not required to speculate about possible future effects subject to future permitting (AS 38.05.035(h)). Therefore, This chapter discusses potential effects of geothermal exploration, development, production, and transportation, that are known or have been made known to the Director and that are significant and reasonably foreseeable. Additional effects of future exploration, development, and production that are unknown at this time may 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.

Potential effects of the geothermal resources exploration and development on Augustine Island 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 or reduced through mitigation measures. Mitigation measures, developed to reduce these impacts, are in Chapter Eight.

In addition to the mitigation measures in Chapter Eight, all post lease activities are subject to local, state, and federal laws, some of which are listed as lessee advisories in Chapter Eight. Refer to Appendix B for a list of statutes and regulations. 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.

Prospect permitting for geothermal exploration and subsequent leasing activities alone are not expected to have any significant effects, other than to provide initial revenue to the state. Post permitting and leasing activities could affect the terrestrial, freshwater, and marine 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. Unintended occurrences such as hazardous waste spills could also have effects.

The discussion below addresses impacts that may occur from geothermal resources recovery activities. The exploration and drilling stages of developing a geothermal resource are often compared to those of the oil and gas industry (Jennejohn 2009). The impacts of these activities may be similar to those for oil and gas recovery activities in Alaska.

## A. Terrestrial Habitats, Wildlife, and Birds

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. 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, wildlife, and birds in and near the disposal area.

## 1. Potential Effects on Terrestrial Habitats, Wildlife, and Birds

During geothermal development, and production, various activities can impact uplands, wetlands, vegetation, and habitats in the disposal area. Direct habitat loss in uplands and wetlands can result from construction of well pads, roads, airfields, processing facilities, housing, and other infrastructure. Effects of construction 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.

### *a. Disturbances*

Potential impacts can occur at all stages, but most are likely to occur during development and production. Exploration activities do not include installing roads, airfields, well pads, facilities, and other infrastructure.

Potential ecological effects of roads include physical disturbance, habitat loss, reduction in population of species in close proximity to the road, dispersal of wildlife, and mortality of wildlife. Habitat fragmentation may be a result, which may impact biological diversity (Spellerberg and Morrison 1998). 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).

Land surface disturbances may change and destroy vegetation, and can alter soils characteristics. Types of land surface disturbances may include vegetation clearing, slash disposal, altered soil characteristics, hydraulic erosion, altered surface hydrology, above ground obstructions, and filled areas (Hanley et al. 1983).

Human activities can damage or remove the vegetative cover, leading to soil erosion (Hanley et al. 1981). The effects can alter the terrestrial habitat, and cause siltation of nearby freshwater habitats. Disturbances can cause melting, erosion, heaving, slumping and subsidence (Hanley et al. 1981). The active layer of soil can undergo changes that cause settling, and can cause draining of areas previously frozen (Hinzman et al. 1997, citing to Lawson 1986 and Waelbroeck 1993). Searching for adequate construction materials can also cause removal of gravel, if available, and disturbance of habitats (Hanley et al. 1983).

### *b. Construction Activities*

If commercially-viable geothermal resources are identified, infrastructure construction may be needed. Effects of constructing production pads, roads, and pipelines can include direct loss of habitat acreage due to gravel and materials infilling, and loss of habitat due to entrainment and diversion of water. Construction of roads and gravel pads can interrupt surface water sheet flow and stream flows (NRC 2003). Prior identification of sensitive areas can support the construction of infrastructure away from sensitive habitats. A secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth (McKendrick 2000; Truett and Johnson 2000).

A study of the impacts to habitats from the construction of the Trans-Alaska Pipeline System found that the greatest percent loss of habitat was from gravel material sites used for construction materials, with the work pad areas and road causing the next greatest habitat loss percentages (Pamplin 1979).

Construction activity involving vehicular passage (see below, Seismic Surveys), such as a Rolligon, may damage habitat. Research shows that differing vegetation types respond differently to the surface use of Rolligon vehicles. The amount of time that is predicted

for full surface revegetation after Rolligon use ranged from 3 to 10 years, with differences attributed to type of vegetation, soil moisture characteristics, and level of disturbance (Jorgenson et al. 2003).

Ecosystems are impacted by roads including potential chemical input from roads to water bodies and to the airshed, and bioaccumulation in soils. Roads can impact fluvial dynamics, sediment transport and floodplain ecology. When roads alter habitats, plant species can be changed or removed, and nonnative plants can be introduced. Additional wildlife habitat impacts from roads can change the density and composition of animal species and populations (NRC 2003). The effects of roads can also include physical disturbance, 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 (Spellerberg and Morrison 1998).

Road construction, vehicular passage, and hazardous substance spills can alter surface albedo (reflectivity of sunlight off the earth's surface) or water drainage patterns, resulting in thaw and subsidence or inundation. Such changes can affect regeneration and revegetation of certain plant species, and species composition may also change after disturbance from construction activities (Linkins et al. 1984).

Major facilities that may be constructed in post-lease development include processing facilities and power generation plants. These facilities can have potential impacts similar to pads, roads, and other infrastructure. 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).

### *c. Seismic Surveys*

Winter seismic surveys can affect vegetation, depending on snow depth, vehicle type, traffic pattern, and vegetation type. Soil-water content, and the freezing and thawing cycles impact soil strength. Water that freezes in the soils impedes the movement of soil particles. In contrast, low soil-water content does not increase soil strength (Lilly et al. 2008). One study showed that while freezing, soil temperatures colder than -2°C did not cause an appreciable increase in frozen soil water, and found that the difference in frozen soil-water content between -2° C and -5°C in early spring was less than autumn freezing conditions (Lilly et al. 2008).

Effects from seismic surveys during any season could be substantial if operations are conducted improperly. Vehicles can leave visible tracks, but the tracks generally disappear with the recovery of the vegetation within a few years, especially in moist or wet vegetation areas. Vehicles using tight turning radii have sheared off upper layers of vegetation, but left rhizomes intact allowing recovery. Dry, snowless ridges and vegetated sand dunes are at higher risk of damage. Damage was observed to shrubs, forbs and tussocks in some studies, and more significant impacts were observed on higher, drier sites, with little to no evidence of damage observed in wetlands (Guyer and Keating 2005). Use of 3D seismic methods may increase the surface footprint of the surveys, as a denser grid of trails is used than in the 2D surveys previously conducted (Jorgenson and Cater 1996).

### *d. Vehicular Traffic*

Numerous waterfowl, seabirds, and shorebirds found on Augustine Island use the area for a stop-over site, staging, and refugia. Disturbance and habitat loss of birds may occur as facilities are developed, on habitats used by birds for nesting, foraging, brood rearing, and molting. For example, regular vehicle traffic could permanently displace nesting birds near the activity. Secondary effects, including changes in drainage patterns, deposition of dust, and disturbance associated with activities, can displace birds. Collision of birds with manmade objects may occur.

Studies conducted about the human effects of the habitats of the Pacific loon in or near oil fields report that disturbances are caused by construction of gravel roads and pad and human activity. Disturbance of nest sites, reduced availability of food sources, and abundance of predators may affect the bird populations (Kertell 2000, citing to Kertell 1996, 1997). The common eider and Lapland longspurs sometime select gravel fill for nesting sites (McKendrick 2000). Changing the water regime with impoundments and limiting movement among wetlands may compromise access to birds' food supply (Kertell 2000, citing to Walker et al. 1987).

The selection of nesting habitat has been more important than oil field facility avoidance (Ritchie and King 2000). Road noise and human presence, including pedestrians, on roads have caused some swans to nest farther from the road than they had previously (>100 to 200 m) (Ritchie and King 2000, citing to Murphy and Anderson 1993).

Disturbance is most likely to have an impact to bird habitat during those periods when birds have difficulty in meeting their daily energy requirements, especially when food intake needs to be high to enable birds to build up nutrient reserves in advance of periods of high demand (MMS 2008).

Effects of aircraft traffic on birds 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 (Rojek et al. 2007). Research relating to aircraft disturbances of common murres along the California coast 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 (Rojek et al. 2007). Helicopters can cause more disturbance due to their low altitude capabilities (Rojek et al. 2007). Flushing and displacing adults or broods from preferred habitats during prenesting, nesting, and brood rearing and migration can cause disruption of courtship, chick loss, egg breakage, and predation by predators (Rojek et al. 2007).

Research by Ward and Sharp (1974) evaluated the impacts of helicopters to moulting sea ducks on Herschel Island, Canada. They found that helicopter disturbances at 100 m height had an immediate impact, but that impacts on bird behavior showed no lasting effects. Helicopter disturbances did not drive birds from the habitat, and helicopter overflights at 300 m did not affect bird behavior (Ward and Sharp 1974).

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) (Ward et al. 1999). The Canada geese were more reactive to helicopter rotary wing aircraft (41percent) and louder aircraft (43 percent), as compared to fixed-wing (20 percent) and low-noise aircraft (31 percent) (Ward et al. 1999). The greatest response was to flights at intermediate altitudes of about 1000 to 2300 ft. Lateral distance from the birds was also a critical factor in determining the amount of disturbance to the birds (Ward et al. 1999).

Larned et al. (1997) found contrasting results about bird impacts from helicopters compared to fixed wing aircraft. They found that eiders tolerated close passes by helicopters at 150 m with mild alarm responses, while fixed wing aircraft caused the entire flock to leave with approaches within 150 to 200 m (Larned et al. 1997).

In research by Rojek, boat vessel approaches to common murre colonies along the coast also caused disturbances, with large disturbances causing some to birds to fly away leaving the habitat, and allowing other bird species to replace them (Rojek et al. 2007).

### *i. Well Blowouts*

During geothermal drilling, highly pressured steam and fluids can be encountered, and there is potential for blowouts (Te Ara Encyclopedia of New Zealand 2011). 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". If this flow is not controlled, it results in a blowout (Finger and Blankenship 2010).

### *ii. Drilling Related Oil and Fuel Spills*

During the construction of the Trans-Alaska Pipeline from January through December, 1975, the most oil spills occurred due to equipment repair, refueling, or vehicular accidents (Kavanagh and Townsend 1977). It was determined that many small spills of less than 50 gal could have been prevented by good maintenance procedures and consistent, careful handling techniques. The large spills of over 50 gal were related to vehicular accidents or faulty fuel facilities in camps (Kavanagh and Townsend 1977). These types and sizes of spills could occur during exploration, development, production, and transportation on or near Augustine Island.

The release of hydrocarbons can have toxic effects on vegetation, soils, wildlife, birds and fish. The characteristics of the soil, such as porosity, permeability, texture, degree of water saturation and organic matter content, can effect oil movement (Jorgenson and Cater 1996). Oil flow depends on many factors, including the volume spilled, type of cover (plant or snow), slope, presence of cracks or troughs, moisture content of soil, temperature, wind direction and velocity, thickness of the oil, discharge point, and ability of the ground to absorb the oil (Linkins et al. 1984). The principal means of oil transport are gravity, water flow, and diffusion in water or air (Jorgenson and Cater 1996). The spread of oil is less when it is thicker, cooler, or is exposed to chemical weathering. If the ground temperature is less than the pour point of the oil, it pools and is easier to contain. If the oil is spilled on snow, it may be absorbed by the snow. Spilled oil that is warmer than snow may melt the snow and flow along the ground under the snow (Linkins et al. 1984, citing to MacKay 1975).

Dry soils have greater porosity and the potential for vertical movement is greater (Linkins et al. 1984, citing to Everett 1978). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects, such as mortality or reduced regeneration, can occur in following seasons (Linkins et al. 1984). Hydrogen degrading bacteria and fungi can act as decomposers of organic material, and under the right conditions can assist in the breakdown of hydrocarbons in soils. Natural or induced bioremediation using microorganisms can also occur (Linkins et al. 1984; Jorgenson and Cater 1996).

Oil may cause harm to wildlife through physical contact, ingestion, inhalation and absorption. Oil toxicity can be related to the content of light aromatic hydrocarbons in the oil (Jorgenson and Cater 1996). As food sources are impacted by oil, larger animals, fish, mammals and humans can in turn be affected (USFWS 2004). Impacts to birds from oil releases may foul plumage and destroy insulation value, and resultant loss of buoyancy or hypothermia can kill birds (Burger and Fry 1993). While cleaning plumage, birds can ingest or inhale the oil, causing potentially lethal damage to lungs, liver, and kidneys. Non-lethal effects to birds can include impaired reproduction or suppression of the immune system (USFWS 2004). Individual animals in the immediate vicinity and the associated nearby habitat and food sources may be impacted. Wildlife species may be disturbed or displaced. Additional efforts may be needed to divert wildlife from access to the impacted area.

Impacts to the terrestrial habitat can also result from disturbances associated with spill cleanup activities. These disturbances may cause positive effects by minimizing

animals' and birds' direct contact with the spill substance. Observations of a wet-sedge meadow affected by a crude oil spill showed that complete vegetation recovery occurred in 20 years without cleanup. In contrast, a dry habitat effected by a crude oil spill recovered to only 5 percent of the vegetation cover after 24 years (McKendrick 2000, citing to McKendrick 1999). Burning as part of oil spill cleanup immediately after the spill is a very effective cleanup method. Heat from a fire will not penetrate deeply into the soil, and recovery will occur naturally (McKendrick 2000).

The action of removal of oil may be more damaging than allowing some residual oil to remain in place, in some cases. Oil weathers over time, and organisms may be able to tolerate the presence of oil while it is naturally degrading (Jorgenson and Cater 1996). The long term effects of oil may persist in the sediments for many years. Shifting of population structure, species abundance, diversity and distribution can be long term effects, especially in areas that are sheltered from weathering processes (USFWS 2004). Active clean-up measures must be planned to avoid additional adverse impacts, such as use of damaging equipment and manpower activities. Passive measures may be the best means to facilitating natural recovery, as in the case of small or contained spills, to minimize adverse effects to habitats (Linkins et al. 1984).

### *iii. Releases of Drilling Muds, Produced Water, and Solid Wastes*

During geothermal exploration well drilling muds and cuttings are stored on-site, in holding tanks, or in a temporary reserve pit, and then hauled to an approved solid waste disposal site are reinjected into the subsurface through an approved injection well. Common drilling fluids contain water, clay, and polymer additives (Finger and Blankenship 2010). The release of drilling muds, produced water, and solid wastes may effect vegetation, soils, wildlife, birds and fish.

Drilling additives may include petroleum or other organic compounds to modify fluid characteristics during drilling (National Driller 2010). The down-hole injection of drilling muds and cuttings are unimportant if they are not placed into the subsurface into a drinking water aquifer (NRC 2003). This injection technique for mud and cutting disposal has greatly reduced the potential adverse impacts caused by releases of drilling muds and reserve pit materials (NRC 2003).

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 (Hahn 1979a). Some of the drilling materials can be caustic or toxic, and worker safety procedures can help to mitigate any harmful effects.

### *iv. 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. In normal geothermal settings, induced seismicity has not been a problem (Massachusetts Institute of Technology 2006). Augustine Island is in an active seismic area, and induced seismic effects are possible. The conventional and enhanced geothermal system technologies used to develop geothermal resources may induce seismicity. Introduction of fractures to increase reservoir permeability and recover heat can create microseismic events.

The potential effects of induced seismicity include vibrations and microseismic events. These events have low energy with relatively short duration, high frequency, very low amplitude, and may go unnoticed (Majer et al. 2008).

### 2. Mitigation Measures

DO&G mitigation measures, along with laws imposed by other federal, state, and local agencies, are expected to avoid, minimize, or mitigate potential negative effects of geothermal exploration, development, and production activities on terrestrial habitats, wildlife, and birds. However, mitigation measures and laws cannot protect all activities and facilities from the actions of a live volcano, such as the Augustine Volcano. DO&G mitigation measures for this disposal area are in Chapter Eight.

## B. Aquatic Habitats, Fish, and Wildlife

### 1. Potential Effects on Aquatic Habitats, Fish, and Wildlife

The marine habitats of the disposal area extend from the shoreline of Augustine Island into the marine waters. These marine habitats are important to several species of fish, seabirds and shorebirds, marine mammals, and other aquatic organisms. Details about the species and habitats of Augustine Island are found in Chapter Four. The area is also important for commercial, sport, and subsistence harvesting activities.

#### *a. Disturbance and Habitat Loss*

Activities related to geothermal exploration, development, production, and transportation that occur within the marine environment could cause short and long term impacts. Potential effects of constructing pads, and roads include direct loss of acreage due to gravel and materials infilling, and loss of habitat due to entrainment and diversion of water. A secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth.

Erosion is a potential impact of all phases of exploration and development. Erosion results in siltation and sedimentation, which in turn may reduce or alter watershed flow, affecting habitat quality.

Withdrawal of water from freshwater bodies can increase habitat disturbance. The construction of trails and roads across rivers and streams may also affect habitats. Improper installation of culverts in streams for permanent roads can cause increased disturbance.

Some marine mammals, or pinnipeds, could be temporarily displaced by construction activities associated with creating a gravel drilling or production pad on land. Onshore development in the limited uplands included in the disposal area could also disturb pinnipeds. However, the amount of displacement is likely to be very small in comparison with the natural variability in seasonal habitat use and is not expected to affect seal populations. Effects are likely to be one year or one season or less, with any disturbance of pinnipeds declining after construction activities are complete (MMS 1996).

Noise and disturbance from pipeline or causeway construction may adversely affect pinnipeds in the area. A 2006 study found ringed seals near an offshore arctic oil field in 2000 and 2001 established lairs and breathing holes in the landfast ice within a few meters of the field before and during the onset of winter oil activity (Williams et al. 2006). These seals' use of the habitat continued undisturbed despite low-frequency noise and vibration, construction, and use of an ice road, indicating their ability to adapt to highly variable habitat availability (Williams et al. 2006).

Offshore construction activities may cause water turbidity. Increased water turbidity may affect biological productivity by preventing sun light from penetrating the water column. However, during the winter, ice, temperature, and lack of sunlight are more influential in

affecting biological productivity than water turbidity. Benthic creatures may be affected by a down current sediment plume. Factors affecting sedimentation are current speed, construction materials, and depth of water (MMS 2003).

Changes to the physical environment may alter patterns of use of the marine habitats. Changing marine current flow and circulation patterns can result in physical changes to shorelines, which could affect use by animals who feed on fish, such as shorebirds and waterfowl (ADF&G 1996).

### *b. Data Acquisition Impacts*

Remote sensing technologies may be used to begin exploration. These technologies include satellite imaging, airborne hyperspectral surveys, and light detection and ranging (Jennejohn 2009). Noise and disturbance from airborne operations can cause a brief disturbance response from land and marine mammals.

Seismic surveys employ acoustic-energy pulses emitted by airguns that would probably be the principle source of impact to marine mammals. Numbers, sighting distances, and behavior of seals were studied during a nearshore seismic program off northern Alaska in 1996 (Harris et al. 2001). During daylight, seals were seen at nearly identical rates during periods with no airguns firing, one airgun, and a "full-array" of 8 to 11 120 cubic inch airguns. Seals tended to be farther away during full-array seismic testing. Seals avoided a 150 m zone away from the boat during full-array seismic, but seals apparently did not move much beyond 250 m. "Swimming away" was more common during full-array than no-airgun periods. Affected animals are likely to return to normal behavior patterns within a short period of time (MMS 1996). Seismic exploration and the presence of drilling rigs could displace seals (MMS 2008).

The available scientific and management literature suggests that mortality of juvenile and adult fish, the age-classes most relevant to future reproductive fitness and growth, likely will not result from seismic-survey activity, and that injury to adult and juvenile fish would be limited to a small number of animals (MMS 2007b).

Vessel traffic may disturb some fish resources and their habitats during seismic operations. However, vessel noise is expected to be transient; fishes in the immediate vicinity of such vessels are believed likely to avoid such noise perhaps by as much as several hundred meters, and vessel noise would likely have negligible impact on fish resources (MMS 2007a).

Additional disturbance may occur with the introduction of hydrophone arrays towed or suspended in the ocean or placed on the seafloor. Seismic surveys typically cover a relatively small area and only stay in a particular area for hours, thereby posing transient disturbances. Adverse effects to the migration, spawning, and hatchling survival of fish most likely would be temporary and localized, and only a moderate level of disturbance or displacement would occur (MMS 2007a).

Seismic surveys are expected to have little or no effect on plankton, because the energy sources (airguns) do not appear to have any adverse effect on this group of organisms. In general, even high explosives have had relatively little effect on marine invertebrates. Airguns are shown to have no lethal effect on caged oysters placed close to the airguns. The use of ocean-bottom cable seismic arrays has the potential to cause harm, although the effect, if any, will probably not be measurable. Seismic activities are, therefore, expected to have little or no effect on lower trophic level organisms (MMS 2008).

### *c. Unintended Releases of Hazardous Substances*

#### *i. Types of Unintended Releases*

The types of materials discharged while drilling include drilling muds and cuttings. Geothermal drilling fluids may contain water and other mixtures that are added to facilitate drilling (Culver 2011).

#### *ii. Drilling and Production Activity Releases*

During production, the main discharge is produced waters. These releases may contain small amounts of hydrocarbons and create plumes of material that disperse rapidly in the water column. In most offshore continental shelf areas, drilling muds and cuttings land on the sea bottom within 1,000 m of the release point. The effect of drilling releases on lower trophic-level organisms appears to be restricted to benthic organisms living nearest to the discharge source. There is no evidence of effects on plankton from drilling muds (MMS 1998).

Drilling muds, cuttings, produced waters, and other effluents from geothermal exploration, development, production, and transportation can have short- and long-term negative effects on aquatic life, including fish and benthic organisms (Olsgard and Gray 1995). Geothermal drilling fluids may contain water and other mixtures of bentonite, dispersants, wetting agents, weighting materials, organic compounds, thinners and lubricants that are added to facilitate drilling (Culver 2011; Tuttle 2006). Releases to water environments that have concentrations above the concentration considered acceptable for aquatic life could cause toxic conditions (Woodward et al. 1988). Significant accumulation of drilling mud in wetlands can potentially impact benthic habitats and can blanket fish spawning grounds (Schmidt et al. 1999, citing to Falk and Lawrence 1973; and citing to Friedheim; Sprague and Logan 1979). Some research shows that bentonite mud may increase and improve the water holding capacity of soil (Schmidt et al. 1999, citing to Luginbuhl 1995). Suspended solids in aquatic habitat can have adverse effects on egg and larval development of amphibians (Schmidt et al. 1999, citing to Richter 1995). Produced waters may contain hydrocarbon and chemical constituents in volumes that may be toxic to microorganisms and mysid shrimp (Mysidopsis bahia) (Brown et al. 1992).

Effects of the discharge of produced waters to benthic organisms will mostly be sublethal, but some of these organisms can be killed (MMS 2003). Discharge of silty material, similar to riverine overflow sediments, may block sunlight and reduce photosynthesis of plankton in the water column. The area of impact is limited to the immediate vicinity of the drill site.

## 2. Mitigation Measures

Geothermal exploration and activities subsequent to leasing could potentially have effects on marine mammals, fish and other marine and aquatic organisms. DO&G mitigation measures, along with laws imposed by other federal, state, and local agencies, can minimize many of the potential negative effects. However, mitigation measures and laws cannot protect all marine mammals, fish and other marine and aquatic organisms from the actions of a live volcano, such as the Augustine Volcano. DO&G mitigation measures for this disposal area are in Chapter Eight.

# C. Air Quality

## 1. Potential Effects on Air Quality

Geothermal resource development can produce emissions that potentially affect air quality. Gases can be emitted into the air from power generation, well testing, leakage of volatile petroleum components, supply activities, and transportation vehicles (Arctic Council 2009). Greenhouse gas emissions (carbon dioxide and methane) are another potential source of air pollution. These emissions come primarily from the burning fossil fuels in generators, vehicles, heavy construction equipment, aircraft, and camp operations. Fugitive sources account for a significant percentage of methane emissions from oil and gas operations.

Geothermal field activities and subsequent power plant air emissions may be composed of water steam vapors (Kagel et al. 2007). Emissions of hydrogen sulfide are possible; however this compound is frequently abated onsite (Kagel et al. 2007). Some localities may have mercury in the geothermal resource, and emissions must undergo abatement prior to release to the environment (Kagel et al. 2007).

On-road and off-road vehicles, heavy construction equipment, and earth-moving equipment could produce emissions from engine exhaust and dust. Sources of air emissions during geothermal drilling operations include rig engines, camp generator engines, steam generators, waste oil burners, hot-air heaters, and incinerators. Emissions could be generated during installation of pipelines and utility lines, excavation and transportation of gravel, mobilization and demobilization of drill rigs, and during construction of gravel pads, roads, and support facilities. Emissions could also be produced by engines, turbines, and heaters used for production, fluids and heat processing, and transport. In addition, aircraft, supply boats, personnel carriers, mobile support modules, as well as intermittent operations such as mud processing and well testing, could produce emissions (MMS 2008).

Well blowouts, evaporation of spilled oil, and burning of spilled oil may also affect air quality. Gas caused blowouts may ignite. A fire could deposit a light, short-term coating of particulates over a localized area. Other effects of reduced air quality include possible damage to vegetation, acidification of nearby areas, and atmospheric visibility impacts (BLM 2005).

## 2. Mitigation Measures

Geothermal activities may affect air quality. Administration of the federal Clean Air Act (42 USC §§ 7401-7671), and the state air quality statutes (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.

# D. Historic and Cultural Resources

## 1. Potential Effects on Historic and Cultural Resources

The disposal area has one documented occurrence of historical and cultural resources: a remote abandoned cabin likely used by pumice miners in the 1940s and early 1950s. The potential future impacts to the resources at this location may be linked to accidental spills, erosion, and vandalism (Dekin et al. 1993).

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 future discovered 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 oil spill cleanup crews collecting artifacts (USFWS 1986).

Spills can have an indirect effect on archaeological sites by contaminating organic material, which would eliminate the possibility of using carbon C-14 dating methods (USFWS 1986). The detrimental effects of cleanup activity on these resources are minor because the work plan for cleanup is constantly reviewed, and cleanup techniques are changed as needed to protect archaeological and cultural resources (Bittner 1996).

### 2. Mitigation Measures

Although there is only one known occurrence on Augustine Island, any historic and cultural resources can be affected by geothermal exploration, development, production, and transportation activities. Various mitigation measures used to protect archaeological sites during spill cleanups include avoidance (preferred), site consultation and inspection, onsite monitoring, site mapping, artifact collection, and cultural resource awareness programs (Bittner 1996).

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 (AHRS 2010).

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, such as the Augustine Volcano. Refer to Chapter Eight for information about mitigation measures.

## E. Potential Fiscal Effects on the State and Communities

The state may lease state land for development of geothermal resources under AS 38.05.035 and 11 AAC 84.700. Leasing activities alone are not expected to have any effects, other than to provide initial revenue to the state. The related revenue sources include bonus bid, rental, and royalty payments.

Developing geothermal resources requires that economics are favorable for power generation. Siting, permitting, and customer markets must overcome the risk of bearing the high exploration and capital investments in the initial development phases (AEA 2009). Power plants must be designed to maximize reservoir potential and sustainability. Adequate financing is required for plant and transmission line construction. 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 (AEA 2009). 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).

A direct benefit of geothermal resources development can be power generation for the Cook Inlet region. The closest power plants to Augustine Island are Beluga and Nikiski (Map 6.1). Homer Electric Association (HEA), an electric utility, serves communities on the east side of Cook Inlet, with over 21,000 member-owners within a 3,166 square-mile service area (HEA 2011). Power generation from geothermal resources in Cook Inlet could augment existing power sources. Transmission of geothermal generated power to local villages, residents and industrial facilities can add to meeting the energy needs of the Cook Inlet area.

### 1. Mitigation Measures

The mitigation measures encourage lessees to employ local Alaska residents and contractors, to the extent they are available and qualified. Lessees must submit, as part of the plan of operations, a plan detailing the means by which the lessee 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.

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# Chapter Eight
# Mitigation Measures and Lessee Advisories

AS 38.05.035(e) and the department delegation of authority provide the Director of DO&G (Director) 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 permits based on these mitigation measures. Mitigation measures are not intended to duplicate or replace an agency's regulatory authority.

Lessees must obtain approval of a detailed plan of operations from the Director before conducting exploration, development, or production activities. 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. It must also address any potential geophysical hazards that may exist at the site.

Lessees 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 Director may grant exceptions to these mitigation measures. Exceptions will only be granted on a showing by the lessee that compliance with the mitigation measure is not practicable and that the lessee 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 review of the plan of operations.

Except as indicated, the mitigation measures do not apply to geophysical exploration on state lands; geophysical exploration activities are governed by 11 AAC 96.

Lessees are notified that mitigation measures may not protect activities and facilities from the effects of Augustine Island's active volcano.

The term “lessee” also includes “prospecting permittee”. The term “lease” also includes “prospecting permit”.

Abbreviations used are:

| Agency | |
|---|---|
| ADF&G | Alaska Department of Fish and Game |
| ADEC | Alaska Department of Environmental Conservation |
| ADNR | Alaska Department of Natural Resources |
| AOGCC | Alaska Oil and Gas Conservation Commission |
| 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 | |
|---|---|
| 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 lessee’s efforts to minimize impacts on residential, commercial, and recreational areas, Native allotments and subsistence use areas. At the time of application, the lessee must submit a copy of the proposed plan of operations to DO&G.

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, in consultation with ADF&G.

c. The siting of onshore facilities, other than docks, roads, utility or pipeline corridors, or terminal facilities will be prohibited within one-half mile of the mean high water of Cook Inlet, except where land use plans classify an area for development, or established usage and use history show development. The siting of facilities other than docks, roads, utility, and pipeline crossings will also be prohibited within 500 ft of

all fish bearing streams and water bodies and 1,500 ft of all current surface drinking water sources. Facilities may be sited within these buffers if the lessee demonstrates to the satisfaction of the Director, in consultation with ADF&G, that site location inside the buffer is environmentally preferred. Road, utility, and pipeline crossings must be consolidated and aligned perpendicular or near perpendicular to watercourses.

d. Impacts to identified wetlands must be minimized to the satisfaction of the Director, in consultation with ADF&G and ADEC. The Director will consider whether facilities are sited in the least sensitive areas. Further, all activities within wetlands require permission from the USCOE (see Lessee Advisories below).

e. Exploration facilities must be temporary unless the Director approves a proposed alternative. Use of gravel structures may be permitted on a case-by-case basis by the Director, after consultation with DMLW and ADF&G. Approval for use of existing structures will depend on the extent and method of restoration needed to return these structures to a usable condition.

f. Pipelines and gravel pads must be designed to facilitate the containment and cleanup of spilled fluids. Onshore pipelines must be located on the upslope side of roadways and construction pads unless an alternative site is environmentally acceptable, as determined by the Director, in consultation with DMLW. Wherever possible, onshore pipelines must be buried where soil and geophysical conditions permit. All pipelines, including flow and gathering lines, must be designed, constructed, and maintained to maximize integrity against climatic conditions, tides and currents, geophysical hazards, corrosion and other hazards as determined on a case-by-case basis.

g. Pipelines that must cross marine waters will be constructed beneath the marine waters using directional drilling techniques, unless the Director, in consultation with ADF&G approves an alternative method based on technical, environmental, and economic justification. Offshore pipelines must be located and constructed to prevent obstruction to marine navigation and fishing operations.

h. 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, in consultation with DMLW, ADF&G, and ADEC and any non-state surface owner, determines that such removal and rehabilitation is not in the state's interest.

i. Gravel mining sites required for exploration and development activities will be restricted to the minimum necessary to develop the field efficiently and with minimal environmental damage. Gravel mine sites required for exploration activities must not be located within an active floodplain of a watercourse unless DMLW, after consultation with ADF&G, approves a proposed alternative, or that a floodplain site would enhance fish and wildlife habitat after mining operations are completed and the site is closed.

j. Lessees 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 may require lessees to adjust production and injection rates or to suspend operations.

k. The state may require lessees to 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 may require lessees to adjust production and injection rates or to suspend operations.

l. Except for approved off-road travel, exploration activities must be supported only by ice roads, winter trails, existing road systems or port facility, or air service, or by vehicles that do not cause significant damage to the ground surface or vegetation. Wintertime off-road travel may be approved in areas where snow and frost depths are sufficient to protect the ground surface. Summertime off-road travel may be authorized subject to time periods and vehicle types approved by DMLW. Exceptions may be granted by DMLW and the Director 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.

m. Public access to, or use of, the lease sale area may not be restricted, except within the immediate vicinity of drill sites, buildings, and other related facilities. Areas of restricted access must be identified in the plan of operations. Lease facilities and operations will not be located so as to block access to or along navigable or public waters, as defined in AS 38.05.

n. Construction of temporary roads may be allowed. In this section, "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 may be prohibited during the exploration stage.

## 2. Habitat, Fish, and Wildlife

a. Detonation of explosives is prohibited in open water areas of fish bearing streams and lakes. Explosives must not be detonated beneath, or in close proximity to fish bearing streams and lakes if the detonation of the explosive produces a pressure rise in the water body greater than 2.7 pounds per square inch (psi) unless the water body, including its substrate, is solidly frozen. Detonation of explosives within or in close proximity to a fish spawning bed during the early stages of egg incubation must not produce a peak particle velocity greater than 0.5 in per second. Blasting criteria have been developed by ADF&G and are available on request from ADF&G. The location of known fish bearing waters within the lease sale area can be obtained from ADF&G.

   The Director may approve the use of explosives for seismic surveys.

b. Removal of water from fish bearing rivers, streams, and natural lakes is subject to prior written approval by DMLW and ADF&G. 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 will be no greater than 1 mm (0.04 in) unless an alternative screen size has been approved by ADF&G. The maximum water velocity at the surface of the screen enclosure may be no greater than 0.4 ft per second unless an alternate velocity has been approved by ADF&G.

c. Removal of snow from fish bearing rivers, streams, and natural lakes will be subject to prior written approval by ADF&G. Compaction or removal of snow cover overlying

fish bearing rivers, streams, and natural lakes will be prohibited, except for approved crossings. If ice thickness is not sufficient to facilitate a crossing, ice or snow bridges may be required.

d. 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. Trumpeter swan nesting sites will be identified by ADF&G at the request of the lessee.

e. The Director, in consultation with ADF&G, will restrict or modify lease related activities if scientific evidence documents the presence of Steller's eiders from the Alaska breeding population in the lease area and it is determined that geothermal exploration and development will impact them or their over-wintering habitat in the near-shore waters of Augustine Island.

f. The Director, in consultation with ADF&G, may impose seasonal restrictions on activities located in and adjacent to important waterfowl and shorebird habitat during the plan of operations approval stage.

g. Permanent, staffed facilities must be sited outside identified brant, white-fronted goose, snow goose, tundra swan, king eider, common eider, Steller's eider, and spectacled eider nesting and brood rearing areas, unless the Director approves a proposed alternative.

h. At this time, there is no evidence to indicate that large terrestrial mammals inhabit Augustine Island. Future project reviews may require additional mitigation measures and lessee advisories if large mammals are encountered during exploration, development, production, or transportation.

### 3. Subsistence and Other Fish and Wildlife Uses

a. Lease-related use will be restricted when DO&G determines it is necessary to prevent unreasonable conflicts between disposal-related activities and subsistence, and commercial, sport, personal use, and educational harvest activities. In enforcing this term DO&G, during review of plans of operation, 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, sport, and educational harvest activities, restrictions may include alternative site selection, requiring directional drilling, seasonal drilling restrictions, and other technologies deemed appropriate by DO&G.

b. Traditional and customary access to subsistence areas will be maintained unless reasonable alternative access is provided to subsistence users. "Reasonable access" is access using means generally available to subsistence users. Lessees will consult nearby communities, and native organizations for assistance in identifying and contacting local subsistence users.

### 4. Fuel, Hazardous Substances, and Waste

a. Secondary containment will be provided for the storage of fuel or hazardous substances. "Secondary containment" means an impermeable diked area or portable impermeable containment structure capable of containing 110 percent of the volume

of the largest independent container. Double walled tanks do not qualify as secondary containment unless an exception is granted for a particular tank.

b. Containers with a storage capacity of greater than 55 gal that contain fuel or hazardous substances will not be stored within 100 ft of a water body or within 1,500 ft of a current surface drinking water source.

c. During equipment storage or maintenance, the site will 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 will attend transfer operations at all times.

e. Vehicle refueling will 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 will be marked with the contents and the lessee's or contractor's name using paint or a permanent label.

g. A fresh water aquifer monitoring well, and quarterly water quality monitoring, may be required down gradient of a permanent above-ground liquid hydrogen storage facility.

h. Waste from operations must be reduced, reused, or recycled to the maximum extent practicable. Garbage and domestic combustibles must be incinerated or disposed of at an approved site in accordance with 18 AAC 60 (See Lessee Advisories, ADEC).

i. New solid waste disposal sites will not be approved or located on state property during the exploration stage. Exceptions may be provided for drilling waste if the facility will comply with the applicable provisions of 18 AAC 60.

j. Wherever practicable, the preferred method for disposal of muds and cuttings from geothermal activities is by underground injection, as regulated by AOGCC. Other methods of disposal will be allowed only upon approval by the Director, in consultation with ADEC and ADF&G.

## 5. Access

a. Exploration activities must be supported by air service, an existing road system or port facility, ice roads, or by off-road vehicles that do not cause significant damage to the vegetation or ground surface. Construction of temporary drill pads, airstrips, and roads may be allowed. Construction of permanent roads may be allowed upon approval by the Director. Unrestricted surface travel may be permitted by the Director and DMLW, if an emergency condition exists.

## 6. Prehistoric, Historic, and Archeological Sites

a. Before the construction or placement of any gravel, or other structure, road, or facility resulting from exploration, development, or production activities, the lessee 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: 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 may result from the activity.

b. The inventory of prehistoric, historic, and archeological sites must be submitted to the Director and to DPOR Office of History and Archaeology. If a prehistoric, historic, or archeological site or area could be adversely affected by an activity, the Director, after consultation with DPOR Office of History and Archaeology, will direct the lessee 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 lessee must report the discovery to the Director as soon as possible. The lessee must make reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the Director, after consultation with the DPOR Office of History and Archaeology and the KPB, has directed the lessee how to take action for its preservation.

## 7. Local Hire, Communication, and Training

a. Lessees are encouraged to employ local and Alaska residents and contractors, to the extent they are available and qualified, for work performed in the lease sale area. Lessees will submit, as part of the plan of operations, a proposal detailing the means by which the lessee will comply with the measure. The proposal must include a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors. The lessee is encouraged, in formulating this proposal, 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 lessee's past and prospective efforts to communicate information about the project with local communities and interested local community groups.

c. A plan of operations application must include a training program for all personnel, including contractors and subcontractors. The program must be designed to inform each person working on the project of environmental, social, and cultural concerns that relate to that person's job. The program must use methods to ensure that personnel understand and use techniques necessary to preserve geological, archeological, and biological resources. In addition, the program must be designed to help personnel increase their sensitivity and understanding of community values, customs, and lifestyles in areas where they will be operating. The program must include an explanation of the applicable laws protecting cultural and historic resources. The program will address the importance of not disturbing archeological, cultural and historic resources and provide guidance on how to avoid disturbance.

### 8. Definitions

a. Facilities: 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.

b. Hazardous substance: an element or compound that, when it enters into or on the surface or subsurface land or water of the state, presents an imminent and substantial danger to the public health or welfare, or to fish, animals, vegetation, or any part of the natural habitat in which fish, animals, or wildlife may be found; or a substance defined as a hazardous substance under 42 USC 9601 - 9675 (Comprehensive Environmental Response, Compensation, and Liability Act of 1980). It does not include uncontaminated crude oil or uncontaminated refined oil (AS 46.09.900).

c. Identified wetlands: areas identified as wetlands by the USCOE under Section 404 of the Clean Water Act.

d. Minimize: 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.

e. Plan of operations: a lease plan of operations under 11 AAC 84.750 or a unit plan of operations under 11 AAC 84.870.

f. Practicable: feasible in light of overall project purposes after considering cost, existing technology, and logistics of compliance with the standard.

g. Reasonable access: access using means generally available to subsistence users.

h. Temporary: no more than 12 months.

## B. Lessee Advisories

Lessees must comply with all applicable local, state, and federal codes, statutes, and regulations in place at the time of a given project or activity. ADNR provides the following lessee advisories to alert lessees to additional obligations and restrictions that government entities other than DO&G may impose on the lessee. These advisories are not intended to be exhaustive or as commentary on the jurisdiction of any government entity or propriety of any code, statute, or regulation. It is the lessee's responsibility to obtain all necessary state, federal or local authorizations or permits relating to lease activities.

### 1. Alaska Department of Environmental Conservation (ADEC)

a. Pursuant to AS 46.04.030, lessees are required to have an approved oil discharge prevention and contingency plan (C-plan) before commencing operations. The plan must include a response action plan to describe how a spill response would occur, a prevention plan to describe the spill prevention measures taken at the facility, and supplemental information to provide background and verification information.

b. Pursuant to state regulations administered by ADEC and the Clean Air Act administered by EPA, lessees are required to obtain air quality permits before

construction and operation. The permits will include air quality monitoring, modeling, and emission control obligations.

c. Unless authorized by an ADEC permit, surface discharge of reserve pit fluids and produced waters is prohibited.

d. Unless authorized by National Pollutant Discharge Elimination System or state permits, disposal of wastewater into fresh water bodies is prohibited.

## 2. Alaska Department of Fish and Game (ADF&G)

a. The measures listed below may be imposed by ADF&G below the ordinary high water mark to protect designated anadromous water bodies and to ensure the free and efficient passage of fish in all fish bearing water bodies. However, exceptions may be authorized with a Fish Habitat permit. Specific information on the location of anadromous water bodies in and near the area may be obtained from ADF&G.

   i. Alteration of riverbanks may be prohibited.

   ii. The operation of equipment, excluding boats, in open water areas of rivers and streams may be prohibited. Except for approved stream crossings, equipment must not be operated within willow stands (Salix spp.).

   iii. Bridges or non-bottom founded structures may be required for crossing fish spawning and important rearing habitats.

   iv. Culverts or other stream crossing structures must be designed, installed, and maintained to provide free and efficient passage of fish.

b. Removal of water from fish bearing water bodies is subject to AS 16.05.841, AS 16.05.871, and 11 AAC 93.035-.147.

c. The use of explosives for seismic activities with a velocity of greater than 3000 ft-per-second in marine waters is prohibited.

d. The Director, in consultation with ADF&G, may impose seasonal restrictions on activities located in and adjacent to important waterfowl, shorebird and seabird habitat during the plan of operations approval stage.

e. Management of legislatively designated state game refuges and critical habitat areas is the co-responsibility of ADF&G, under AS 16.20.050-.060 and AS 16.20.500-.530, and ADNR, under AS 38.05.027. For activities occurring within a refuge or critical habitat area, the lessee will be required to obtain authorizations and permits from both ADNR and ADF&G.

## 3. Alaska Department of Natural Resources, Office of History and Archaeology

a. Under AS 11.46.482, criminal mischief in the third degree occurs when a “person knowingly defaces, damages, or desecrates a cemetery or the contents of a cemetery or a tomb, grave or memorial regardless of whether the tomb, grave, or memorial is in a cemetery or whether the cemetery, tomb, grave, or memorial appears to be abandoned, lost, or neglected; or removes human remains or associated burial artifacts from a

cemetery, tomb, grave, or memorial regardless of whether the cemetery, tomb, grave, or memorial appears to abandoned, lost, or neglected."

b. The Alaska Heritage Resource Survey data set is comprised of "restricted access documents" and specific site location data should not appear in final reports or be distributed to others.

c. Under AS 41.35.010, the Alaska Historic Preservation Act states, "It is the policy of the state to preserve and protect the historic, prehistoric, and archaeological resources of Alaska from loss, desecration, and destruction so that the scientific, historic, and cultural heritage embodied in those resources may pass undiminished to future generations."

d. Under AS 41.35.200, unlawful acts are when a person may not appropriate, excavate, remove, injure, or destroy, without a permit from the Commissioner, any historic, prehistoric, or archaeological resources of the state. "Historic, prehistoric, or archaeological resources" includes deposits, structures, ruins, sites, buildings, graves, artifacts, fossils, or other objects of antiquity which provide information pertaining to the historical or prehistorical culture of people in the state as well as to the natural history of the state (AS 41.35.230(2)).

e. Under AS 41.35.210, criminal penalties are required for a person who is convicted of violating a provision of AS 41.35.010 –.240. The person is guilty of a class A misdemeanor.

f. Under AS 41.35.215, civil penalties are required in addition to other penalties and remedies provided by law. A person who violates a provision of AS 41.35.010 –.240 is subject to a maximum civil penalty of $100,000 for each violation.

## 4. Alaska Department of Natural Resources (ADNR)

a. Removal of gravel from state land must have prior approval from DMLW, under AS 38.05.110-.120, AS 38.05.810, and 11 AAC 71.045.

## 5. Alaska Department of Labor and Workforce Development

a. The lessee will facilitate Alaska resident hire monitoring by reporting project wages on a quarterly basis for each individual employed by the lessee in the lease area, through electronic unemployment insurance reporting, and by requiring the same of the lessee's contractors and subcontractors.

## 6. U.S. Army Corps of Engineers (USCOE)

a. A U.S. Army Corps of Engineers permit is required when work is anticipated on, in, or affects navigable waters or involves wetland related dredge or fill activities. A Section 10 permit is required for construction, excavation, or deposition of material in, over, or under navigable waters, or for any work which would affect the course, location, condition, or capacity of navigable waters, or for any work which would affect the course, location, condition, of capacity of navigable waters (33 USC 403). A Section 404 permit (33 USC 404) authorizes the discharge of dredged and fill material into waters and wetlands of the United States. The process is similar for both permits and, at times, both may be required.

## 7. U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration

a. Any pipeline used for transportation of gas or hazardous liquids may be subject to federal pipeline safety laws (49 USC 60101 et seq.) and regulations (49 CFR 190-195) under the jurisdiction of the USDOT, Pipeline and Hazardous Materials Safety Administration.

## 8. U.S. Fish and Wildlife Service and National Marine Fisheries Service

a. Migratory birds, sea otters, polar bears, and Pacific walrus are managed by the U.S. Fish and Wildlife Service. The National Oceanic and Atmospheric Administration, National Marine Fisheries Service is responsible for management of all other marine mammals. The lessee is advised that the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.) protects the following endangered or threatened species and candidate species for listing that may occur in the disposal area:

| Species | Status |
|---|---|
| Beluga whale (Cook Inlet stock) | Endangered |
| Northern sea otter | Threatened |
| Spectacled eider | Threatened |
| Steller's eider (Alaska breeding population) | Threatened |
| Steller sea lion (west of 144° longitude) | Endangered |
| Steller sea lion (east of 144° longitude) | Threatened |

b. Lessees to comply with the Migratory Bird Treaty Act (MBTA; 16 USC 703) administered by the USFWS. Under the MBTA, it is illegal to "take" migratory birds, their eggs, feathers or nests. "Take" is defined (50 CFR 10.12) to include "pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting." The MBTA does not distinguish between "intentional" and "unintentional" take. Migratory birds include songbirds, waterfowl, shorebirds, and raptors. In Alaska, all native birds except grouse and ptarmigan (which are protected by the State of Alaska) are protected under the MBTA.

c. In order to ensure compliance with the MBTA, it is recommended that lessees survey the project area before construction, vegetation clearing, excavation, discharging fill or other activities which create disturbance, and confirm there are no active migratory bird nests. It is recommended lessees contact the USFWS for assistance and guidance on survey needs, and other compliance issues under the MBTA. While the USFWS can recommend methods (such as surveys and timing windows) to avoid unintentional take, responsibility for compliance with the MBTA rests with lessees.

d. Lessees to comply with the provisions of the Marine Mammal Protection Act of 1972, as amended (16 USC 1361-1407). The lessee is advised to annually acquire updated information from these agencies. USFWS shares authority for marine mammals with the NMFS.

e. The lessee is advised that off-shore activity (particularly seismic geophysical surveys) may result in the taking of beluga whales and other marine mammals. Such taking is prohibited by the federal MMPA unless otherwise authorized. The incidental taking of marine mammals may be authorized under the MMPA, and lessee is advised to discuss this matter with NMFS in advance of any geophysical survey activity.

f. Critical habitat for beluga whales has been designated within Cook Inlet. It is the lessee's responsibility to obtain all necessary state, federal, and local authorizations or permits relating to prospecting permit and lease activities.

g. The lessee is advised that the description of the techniques used to drill and conduct seismic operations should be thorough and assess potential effects of fish and their spawning substrate, migratory corridors, and over-wintering areas.

h. Lessees are advised that the Magnuson-Stevens Fishery Conservation and Management Act requires identification of Essential Fish Habitat (EFH) for all species managed under a federal Fisheries Management Plan. Subsequent exploration and development activities associated with the lease sale may be subject to consultation under EFH. EFH information, consultation, guidance, and species life history information are available from NMFS.

## 9. Kenai Peninsula Borough (KPB)

a. The Kenai Peninsula Borough has ordinances that govern land and water uses within the Borough. Refer to KPB Title 17 relating to land use of borough lands for more information. It is the lessee's responsibility to obtain all necessary local authorizations and permits relating to lease activities.

The following public comments were timely received during the calls for information:

### 1. ADNR, Office of Habitat Management and Permitting[1] (Scott MacLean, Habitat Biologist)

***Comment Summary:*** Mr. MacLean noted the significant presence of Pacific herring and Pacific halibut in the vicinity of Augustine Island. Mr. MacLean provided OHMP-recommended mitigation measures.

***ADNR Response:*** Lessee must comply with the provisions of ADF&G statutes and regulations governing fish habitat and movement. Mitigation measures A.2.a. - c. are adopted from OHMP-recommended mitigation measures.

### 2. ADNR (Bruce Talbot, Project Manager, Kenai Area Plan)

***Comment Summary:*** Mr. Talbot stated that the management intent for the island does not include long-term uses, except for research and education purposes because of the hazards and liabilities associated with the active volcano. He noted that the north and west shores of the island support eelgrass beds which are important anchorage for the commercial fishing fleet.

***ADNR Response:*** The mitigation measures in Chapter 8 are expected to avoid, minimize, or mitigate potential negative effects of geothermal exploration, development, and production activities. However, mitigation measures and laws cannot protect all activities and facilities from the actions of a live volcano. Therefore, the lessee assumes all liability for its exploration, development, production, and transportation activities and facilities on the island. Refer to Appendix C, Sample Geothermal Lease Agreement for indemnity language. Mitigation measure 3a requires the lessee to make reasonable efforts to ensure that exploration, development, and production activities are compatible with a variety of activities, including commercial activities.

### 3. DGGS (Chris Nye, Geologist V, Chief, Volcanology Section, Liaison to AVO)

***Comment Summary:*** Mr. Nye stated that the entire area is a high-risk area for infrastructure development. Mr. Nye noted that if a geothermal resource is discovered, hazards from future volcanic eruptions should be carefully considered before developing infrastructure for the exploration of that resource. He stated that the DGGS recommends that no permanent infrastructure be placed on the island.

***ADNR Response:*** The mitigation measures in Chapter 8 are expected to avoid, minimize, or mitigate potential negative effects of geothermal exploration, development, and production activities. However, mitigation measures and laws cannot protect all activities and facilities from the actions of a live volcano. Therefore, the lessee assumes all liability for its exploration, development, production, and transportation activities and facilities on the island. Refer to Appendix C, Sample Geothermal Lease Agreement for indemnity language.

[1] The Office of Habitat Management and Permitting (OHMP) of the Alaska Department of Natural Resources (ADNR) became the Division of Habitat, a part of the Alaska Department of Fish and Game (ADF&G), effective July 1, 2008, as a result of Executive Order 114.

### 4. ADF&G (Tracy Lingnau, Region II Management Coordinator)

***Comment Summary:*** Mr. Lingnau stated that the biological concerns are for herring, which used to be commercially abundant in the area, but have not recovered for a number of years. He stated that geothermal exploration in these waters could be disruptive to herring, but is not likely to appreciably threaten them unless the forms of exploration are radical (e.g., blasting).

***ADNR Response:*** Mitigation measure 2a addresses detonation of explosives and lists measures that may be imposed by ADF&G to protect fish and fish habitat.

### 5. U.S. Coast Guard (Cap. M.J. Dreier, Commander)

***Comment Summary:*** Captain Dreier stated that the proposed exploration area is away from any significant shipping routes, and that exploration and development of the area will not have a significant impact on the maritime public.

***ADNR Response:*** The Director considered this comment.

### 6. Homer Electric Association (Brad Janorschke, General Manager)

***Comment Summary:*** Mr. Janorschke provided a history of geothermal energy in Alaska and its potential benefit to local citizens, and urged ADNR to develop geothermal resources on the island.

***ADNR Response:*** The Director considered this comment.

### 7. The Pratt Museum

***Comment Summary:*** The museum recommended that exploration on Augustine Island not go forward.

***ADNR Response:*** The Director considered this comment.

### 8. Cook Inlet Keeper

***Comment Summary:*** The Cook Inlet Keeper commented on the remoteness of Augustine Island and expressed reservations about supporting geothermal exploration due to the island's distance from existing infrastructure.

***ADNR Response:*** The Director considered this comment.

### 9. ADNR, Division of Parks and Outdoor Recreation (Judith Bittner, State Historic Preservation Officer)

***Comment Summary:*** Ms. Bittner requested that the DO&G forward all information to the Office of History and Archaeology for review under Section 41.35.070 of the Alaska Historic Preservation Act.

***ADNR Response:*** Mitigation Measure 6 requires that lessees conduct an inventory of prehistoric, historic, and archeological sites within the area affected by an activity and submit it to the State Historic Preservation Officer. If new sites are discovered during permit or lease operations, the

lessee must make reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the director, after consultation with the DPOR Office of History and Archaeology and the KPB, has directed the lessee how to take action for its preservation.

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# Laws and Regulations Pertaining to Geothermal Exploration, Development, Production, and Transportation

## A. Alaska Statutes (AS) and Administrative Code (AAC) Sections

### 1. Alaska Department of Natural Resources (ADNR)

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|---|---|
| AS 38.05.027 | Management of legislatively designated state game refuges and critical habitat areas is joint responsibility of ADF&G (AS 16.20.050-060) and ADNR. Lessees are required to obtain permits from both ADNR and ADF&G. |
| AS 38.05.127 | Provides for reservation of easements to ensure free access to navigable or public water. |
| AS 38.35.010 to AS 38.35.260 | Right-of-way leasing for pipeline transportation of crude oil and natural gas is under control of commissioner of ADNR. Commissioner shall not delegate authority to execute leases. |
| AS 38.05.945 | These define the requirements for public notice of state decisions. |
| AS 41.08.020 | Defines the requirement for geological and geophysical surveys to potential for production of metals, minerals, fuels and geothermal resources. |
| 11 AAC 51.045 | Easements to and along navigable or public water. |
| 11 AAC 55.075 | Defines geothermal land. |
| 11 AAC 82.605 | Defines and establishes methods for assignments of mineral rights. |
| 11 AAC 83.158(a) | Plan of operations for all or part of leased area or area subject to oil and gas exploration license must be approved by ADNR commissioner before any operations may be undertaken on or in leased or licensed area. |
| 11 AAC 96.010 | Operations requiring permits, including use of explosives and explosive devices, except firearms. |
| 11 AAC 96.025 | Generally allowed land use activities are subject to general stipulations that will minimize surface damage or disturbance of drainage systems, vegetation, or fish and wildlife resources. |

## 2. ADNR, Division of Oil and Gas (DO&G)

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| AS 38.05.035(a)(8)(C) | Requires geological and geophysical data to be kept confidential upon request of supplier. |
| AS 38.05.130<br>11 AAC 83.155 | Allows DO&G director to approve oil and gas exploration and development activities in cases where surface estate is not held by state or is otherwise subject to third-party interests, provided director determines that adequate compensation has been made to surface estate holder for any damages that may be caused by lease activities. |
| AS 38.05.131-145<br>11 AAC 82 | Establishes oil and gas exploration licensing program. |
| AS 38.05.180 | Establishes oil and gas leasing and gas only leasing programs to provide for orderly exploration for and development of petroleum resources belonging to the State of Alaska. |
| AS 38.05.181-182 | Authorizes the director to grant prospecting permits and leases to explore, develop or use geothermal resources. |
| 11 AAC 84.700-950 | Establishes procedures for competitive and noncompetitive leasing of geothermal resources. |
| 11 AAC 87.010-290 | Establishes requirements for exploration operations, drilling and production for geothermal wells and related facilities. |
| 11 AAC 96.010 to<br>11 AAC 96.110 | Provides controls over activities on state lands in order to minimize adverse activities; applies to geophysical exploration permit. |
| 11 AAC 83.158 | Requires a lease plan of operations. |

## 3. ADNR, Division of Mining, Land and Water (DMLW)

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| AS 38.05.075 | Governs public auctions for leasing lands (including tidelands and submerged lands) — procedures, bidding qualifications, and competitive or noncompetitive bidding methods. |
| AS 38.05.110-120;<br>11 AAC 71 | Authorizes the director to issue sand, gravel and rock material and timber for sale. Determines requirements for competitive and negotiated sales. |
| AS 38.05.850 | Authorizes the director to issue permits, rights-of-way, or easements on state land for recovery of minerals from adjacent land under valid lease. |
| 11 AAC 80.005 to<br>11 AAC 80.085 | Establishes pipeline right-of-way leasing regulations. |
| 11 AAC 93.040 to<br>11 AAC 93.130 | Requires a water rights permit for appropriation of state waters. |
| 11 AAC 93.210 to<br>11 AAC 93.220 | Provides for temporary water use permits and application procedures. |

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| 11 AAC 96.010 to 11 AAC 96.110 | Land use permit activities not permitted by multiple land use permit or lease operations approval. |

## 4. Office of History and Archaeology (ADNR)

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| AS 41.35.200 to AS 41.35.230 | Governs the preservation and protection of the historic, prehistoric, and archaeological resources from loss, desecration and destruction, for the continued use by the people and future generations of the State of Alaska. |
| 11 AAC 16.010 to 11 AAC 16.900 | Defines the processes and procedures for reporting, obtaining permits, surveying, investigation, and collection of historic, prehistoric or archaeological resources of the state. |

## 5. Alaska Department of Fish and Game (ADF&G)

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| AS 16.05.841 | Requires that an obstruction across a fishbearing stream provide for fish passage. |
| AS 16.05.871 | Provides for protection of anadromous fish and game in connection with construction or work in beds of specified water bodies and calls for approval of plans by ADF&G for construction of hydraulic project or any use, diversion, obstruction, change, or pollution of these water bodies. |
| AS 16.20 | Manages legislatively designated game refuges, sanctuaries, and critical habitat areas. |
| AS 16.20.060 and AS 16.20.530 | Commissioner, ADF&G, may require submission and written approval of plans and specifications for anticipated use and construction work and plans for proper protection of fish and game (including birds) within legislatively designated game refuges, critical habitat areas, and sanctuaries. |
| AS 16.20.180 to AS 16.20.210 | Requires measures for continued conservation, protection, restoration, and propagation of endangered fish and wildlife. |
| 5 AAC 95.010 | Atlas and catalog of waters important for spawning, rearing, or migration of anadromous fish. Permit application procedures. |

## 6. Alaska Oil and Gas Conservation Commission (AOGCC)

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| AS 31.05.005 | Establishes and empowers AOGCC. |
| AS 31.05.030(d)(9) | Requires oil and gas operator to file and obtain approval of plan of development and operation. |
| AS 41.06.010-060 | Establishes jurisdiction over geothermal resources, waste prohibition, authorities, unitization, reservoir management, and permits to drill for geothermal resources. |

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| AS 46.03.100 | Standards and limitations for accumulation, storage, transportation, and disposal of solid or liquid waste or heated process or cooling water. |
| AS 46.03.900(35) | Defines waste. |
| 20 AAC 25 | Requires permit to drill, to help maintain regulatory control over drilling and completion activities in state. Regulates well spacing and underground injection. |
| 20 AAC 25.140 | Requires authorization to allow an abandoned oil and gas well to be converted to a freshwater well. |

## 7. Alaska Department of Environmental Conservation (ADEC)

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| AS 26.23.900(1) | Defines Alaska State Emergency Response Commission. |
| AS 44.46.028 | Exempts flow-through hot springs from water quality regulation. |
| AS 46.03 | Sets state policy; to conserve, improve, and protect the state's natural resources and environment, and control water, land, and air pollution. |
| AS 46.03.100 | Requires solid waste disposal permits. |
| AS 46.03.759 | Establishes maximum liability for discharge of crude oil at $500 million. |
| AS 46.03.900(35) | Defines waste and other ADEC related terms. |
| AS 46.04 | Oil and Hazardous Substance Pollution Control Act. Prohibits discharge of oil or any other hazardous substances unless specifically authorized by permit; requires those responsible for spills to undertake cleanup operations; and holds violators liable for unlimited cleanup costs and damages as well as civil and criminal penalties. |
| AS 46.04.030 | Requires lessees to provide oil discharge prevention and contingency plans (C-plans). Also provides regulation of aboveground storage facilities that have capacities of greater than 5,000 bbl of crude oil or greater than 10,000 bbl of noncrude oil. |
| AS 46.04.050 | Exemptions for oil terminal facilities that have capacities of less than 5,000 bbl of crude oil or less than 10,000 bbl of noncrude oil. |
| 18 AAC 50 | Provides for air quality control, including permit requirements, permit review criteria, and regulation compliance criteria. |
| 18 AAC 50.316 | Preconstruction review for construction or reconstruction of major source of hazardous air pollutants. |
| 18 AAC 60.265 | Requires proof of financial responsibility before a permit for operation of hazardous waste disposal facility may be issued. |

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| 18 AAC 60.200 | Requires a solid waste disposal permit. |
| 18 AAC 60.430(a)(2) | General requirement for containment structures used for disposal of drilling wastes. |
| 18 AAC 70 | Sets water quality standards. |
| 18 AAC 72 | Protects public health, public and private water systems, and the environment from diseases transmitted by domestic wastewater by establishing minimum treatment, construction, operation, and maintenance standards for domestic wastewater treatment works and disposal systems. |
| 18 AAC 75.005 to 18 AAC 75.025 | Requirements for oil storage facilities for oil pollution prevention. |
| 18 AAC 75.065 to 18 AAC 75.075 | Requirements for oil storage tanks. |
| 18 AAC 75.080 | Facility piping requirements for oil terminal, crude oil transmission pipeline, and exploration and production facilities. Requires a corrosion control program. |
| 18 AAC 75.235 | Sets financial responsibility levels for oil discharges |
| 18 AAC 75.300 | Requires ADEC be notified of spill of oil and other hazardous substances. |
| 18 AAC 75.400 to 18 AAC 75.496 | Requires oil discharge contingency plans and specifies their contents. |

# B. Federal Laws and Regulations

Notes: CFR is the Code of Federal Regulations; USC is the United States Code.

## 1. Clean Water Act and Amendments

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| 33 USC §§ 1251 to 1387 | Establishes water pollution controls to restore and maintain the integrity of U.S. waters |
| 33 USC § 1344 | Requires a COE Section 404 permit to excavate, fill, alter, or otherwise modify course or condition of navigable or U.S. coastal waters and to discharge dredge-and-fill material |
| 40 CFR 435.30-32 | Regulations to prohibit the discharge of water pollutants from any source associated with oil and gas production, field exploration, drilling, well completion, or well treatment. |

## 2. Oil Pollution Act of 1990

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| 33 U.S.C. §2701 et seq. (1990) | This statute focuses on prevention and response to oil spills. It sets forth requirements for planning, reporting and implementing spill prevention and response actions at specific facilities, and on a regional scale. |

## 3. Environmental Protection Agency (EPA)

Oil and other hazardous substance regulations.

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| 40 CFR § 109 | Establishes criteria for oil removal (spill) contingency plans |
| 40 CFR § 110 | Requires reporting of spills |
| 40 CFR § 112 | Oil pollution prevention, designed to form a comprehensive federal/state spill prevention program that minimizes the potential for discharges |
| 40 CFR § 112.7 | General requirements for spill prevention, control, and countermeasures plan |
| 40 CFR § 113 | Sets liability limits for small onshore storage facilities (oil) |
| 40 CFR § 116 | Designates hazardous substances |
| 40 CFR § 117 | Determination of reportable quantities for hazardous substances |

Water quality regulations.

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| 40 CFR § 121 | State certification of activities requiring federal license or permit which may result in any discharge into navigable waters |
| 40 CFR § 122 | NPDES permit regulations |
| 40 CFR § 125 | Sets criteria and standards for NPDES permits |
| 40 CFR § 129 | Sets toxic pollutant effluent standards and lists toxic pollutants |
| 40 CFR § 136 | Establishes test procedures for the analysis of pollutants |
| 40 CFR § 401 | Prescribes effluent limitations guidelines and standards |
| 40 CFR § 435 | Sets discharge criteria for onshore and offshore facilities |

Underground injection regulations.

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| 40 CFR § 144 | Requirements for underground injection control program |

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| 40 CFR § 146 | Sets technical criteria and standards for the underground injection control program |
| 40 CFR § 147 | Sets forth state-administered underground injection control program |

Ocean dumping regulations.

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| 40 CFR §§ 220 to 228 | Regulations, permits, and criteria related to dumping of material in the ocean |

Materials discharge and disposal regulations.

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| 40 CFR § 230 | Regulates the discharge of dredged or fill material into navigable waters |
| 40 CFR § 231 | Sets the procedures for approving or prohibiting disposal of dredged or fill material at a site |

Oil and other hazardous substance pollution regulations.

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| 40 CFR § 300 | National Oil and Hazardous Substances Pollution Contingency Plan, to provide for efficient, coordinated, and effective response to discharges of oil and hazardous substances |

## 4. U.S. Coast Guard, Department of Homeland Security

Regulations relevant to a determination of a hazard to navigation and oil spills in navigable waters.

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| 33 CFR § 64.31 | Determination of hazard to navigation |
| 33 CFR §§ 153 to 158 | Prescribes regulations concerning notification to the Coast Guard of the discharge of oil or hazardous; the procedures for the removal of a discharge of oil; the costs that may be imposed or reimbursed for the removal of a discharge; and for the transfer of oil to, from, or within vessels |

## 5. U.S. Army Corps of Engineers

Navigable waters regulations.

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| 33 CFR § 209.200 | Regulations governing navigable waters |
| 33 CFR §§ 320 to 327 and 330 | Prescribes policies and procedures applicable to review of applications for certain activities in U.S. waters, including discharge of dredged or fill material, including nationwide permits |
| 33 CFR §§ 328 and 329 | Defines waters and navigable waters of the U.S. |

## 6. Fish and Wildlife Coordination Act

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| 16 USC § 662(a) | Requires consultation between agencies on activities conducted in waters. |

## 7. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

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| 42 USC §§ 9601 to 9675 | Defines and designates hazardous substances, sets quantities for reportable releases, and sets cleanup standards |

## 8. Safe Drinking Water Act

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| 42 USC § 300 (f) to (h) | Regulates public water systems to ensure their safety |
| 40 CFR Parts 144 & 145 | These are the requirements for the federal Underground Injection Control Program (UIC), which is responsible for regulating the construction, operation, permitting, and closure of injection wells that place fluids underground for storage or disposal. It includes fluids and waste management for oil and gas activities. |

## 9. Solid Waste Disposal Act, as amended by Resource Conservation and Recovery Act

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| 42 USC §§ 6901 to 6991 | Regulates solid waste disposal planning and management and sets reduction or elimination of hazardous waste as national policy |

## 10. Clean Air Act

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| 42 USC §§ 740l to 7671 | Encourages and promotes reasonable governmental actions for air pollution prevention; sets standards, and permit requirements |

## 11. Toxic Substances Control Act

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| 15 USC §§ 2601 to 2655 | Controls toxic substances, including asbestos |

## 12. National Environmental Policy Act (NEPA)

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| 42 USC §§ 4321 to 4347 | Sets environmental policy; requires a detailed statement of environmental impacts in reports on proposed federal actions significantly affecting the quality of the environment. |

Council on Environmental Quality-administers NEPA-related regulations

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| 40 CFR §§ 1500 to 1508 | Provides regulations applicable to and binding on federal agencies for implementing NEPA, including when and whether to prepare and environmental impact statement |

## 13. Endangered Species Act

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| 16 USC §§ 1531 to 1543 | Interagency cooperation, prohibited acts, penalties, and enforcement |

## 14. U.S. Fish and Wildlife Service (USFWS)

Threatened and endangered species regulations

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| 50 CFR § 17 | Threatened and endangered wildlife and plant species |
| 50 CFR § 402 | Directs federal agencies to further the purposes of the Endangered Species Act |

## 15. Pipeline Inspection, Protection, Enforcement, and Safety Act (PIPES Act) of 2006

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| 49 CFR § 192 | Prescribes minimum safety requirements for pipeline facilities and the transportation of gas |
| 49 CFR § 195 | Prescribes safety standards and reporting requirements for pipeline facilities used in the transportation of hazardous liquids or carbon dioxide |

## 16. Migratory Bird Treaty Act

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| 16 USC §§ 703 to 712 and 715 | Protects migratory birds, per the act and international treaties |

## 17. Archaeological and Historic Preservation Act

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| 16 USC § 469 | Preserves historical and archaeological data that might be lost or destroyed due to a federally licensed activity |

### 18. National Historic Preservation Act

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| 16 USC § 470 | Protects prehistoric and historic resources |

### 19. Occupational Safety & Health Administration

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| PL 91-596, 84 STAT. 1590 | This law establishes the requirements to assure safe and healthful working conditions, enforcement of federal safety standards, and promotes education and training for occupational safety and health. |

### 20. Leases and Permits on Restricted Properties

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| 25 CFR § 162 | Leasing and permitting on Native and restricted lands |

## C. Local Laws and Regulations

### 1. Kenai Peninsula Borough (KPB)

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| Title 17 | Kenai Peninsula Borough land management regulations, planning, and permitting powers. |

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES

Competitive Geothermal Resources Lease ADL NO. «ADL»

THIS LEASE is entered into between the State of Alaska, "the state," and

**«Lessee» «LesseePercent»%**

"the lessee."

In consideration of the cash bonus and the first year's rental, and subject to the provisions of this lease, including any exhibits and addendums attached to this lease, and by reference incorporated in this lease, the state and the lessee agree as follows:

1. GRANT. (a) The state grants to the lessee:

(1) the exclusive right to explore for, develop, or use all of the geothermal resources in or upon the following tract of land:

**Tract «TractNo»**

**«Legal»**

containing approximately **«Acres»** acres, more or less (referred to as the "leased area"); and

(2) the right, subject to reasonable concurrent uses as determined by the state, to use the surface to explore for, develop, or use geothermal resources located within the leased area, subject to the lessee obtaining the required federal, state, borough and municipal agency approvals, as required by law, such approval not to be unreasonably withheld

(b) For the purposes of this lease, the leased area contains the legal subdivisions as shown on the attached plat marked Exhibit A.

(c) The state makes no representations or warranties, express or implied, as to title, or access to, or quiet enjoyment of, the leased area. The state is not liable to the lessee for any deficiency in title to the leased area, nor is the lessee or any successor in interest to the lessee entitled to any refund due to deficiency in title for any rentals, bonuses, or royalties paid under this lease.

2. RESERVED RIGHTS. (a) The state reserves all rights not expressly granted to the lessee by this lease. These reserved rights include:

(1) The right to conduct geological and geophysical surveys within the leased area;

(2) The right to explore for, develop, and remove natural resources other than geothermal resources on or from the leased area;

(3) The right to establish or grant easements and rights-of-way upon, through, or within the lease area for any lawful purpose;

(4) The right to dispose of land within the leased area for well sites and well bores of wells drilled from or through the leased area to explore for or produce geothermal resources in and from lands not within the leased area; and

(5) The right otherwise to manage and dispose of the surface of the leased area or interests in that land by grant, lease, permit, or otherwise to third parties;

3. TERM. This lease is issued for a primary term of ten (10) years from the effective date of this lease.

4. RENEWAL AND EXTENSION. (a) After the expiration of the primary term, this lease may be renewed for one additional term of five years if, at the end of the primary term, the lessee is diligently conducting operations necessary to drill a geothermal well, with equipment at the lease area of sufficient size and capacity to drill to the total depth proposed for the well.

(b) This lease will be extended for the duration of commercial production of geothermal resources from the leased area.

(c) If the state issues a written direction to suspend operations or production from the leased area or issues a written approval of such action, a period of time equivalent to the period of suspension will be added to the lease term.

(d) If the state determines that the lessee has been prevented by force majeure, after efforts made in good faith, from performing any act that would extend the lease, it will not expire during the period of force majeure and the state will grant a reasonable extension of time which may be different than the period of force majeure.

(e) Nothing in subparagraph (c) or (d) suspends the obligation to pay royalties or other production or profit-based payments to the state from operations on the leased area that are not affected by any suspension or force majeure, or suspends the obligation to pay rentals.

5. RENTALS. (a) The lessee shall pay annual rental to the state in the amount of $3.00 per acre or fraction of an acre, provided that the state may adjust the annual rental rate as provided by applicable law beginning 20 years after the commencement of commercial production and at ten year intervals thereafter.

(b) The lessee shall pay the annual rental to the state in advance, on or before the annual anniversary date of this lease. If the state's (or depository's) office is not open for business on the annual anniversary date of this lease, the time for payment is extended to include the next day on which that office is open for business. If the annual rental is not paid timely, this lease automatically terminates as to both parties at 11:59 p.m., Alaska Standard Time, on the date by which the rental payment was to have been made.

(c) The rental for a year shall be credited against royalties accruing for that year.

6. RECORDS. The lessee shall maintain records showing the development and production (including records of development and production expenses) and disposition (including records of sales prices, volumes, and purchasers) of all geothermal resources produced from the leased area. The lessee shall permit the state or its agent to examine these records at all reasonable times, and to make copies of those records. Upon request by the state, the lessee's records shall be made available to the state at the state office designated by the state. The lessee's records of development, production, and disposition must employ methods and techniques that will ensure the most accurate figures reasonably available. The lessee shall use generally accepted accounting principles (GAAP) consistently applied for its financial accounting records. The state is entitled to review all other relevant documents including those not subject to GAAP.

7. PAYMENTS. All payments to the state under this lease must be made payable to the State of Alaska, Department of Natural Resources in the manner directed by the state, and unless otherwise specified, must be tendered to the state at:

DEPARTMENT OF NATURAL RESOURCES
ATTENTION: FINANCIAL SERVICES SECTION
550 West 7th Avenue, Suite 1410
Anchorage, Alaska 99501-3561

or in person at either of the Department's Public Information Centers located at:

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| 550 W. 7th Avenue, Suite 1260<br>Anchorage, Alaska | 3700 Airport Way<br>Fairbanks, Alaska |

or to any depository designated by the state with at least 60 days notice to the lessee.

8. PLAN OF OPERATIONS. (a) Except as provided in (b) of this section, a plan of operations for all or part of the leased area must be approved by the state before any operations may be undertaken on or in the leased area.

(b) A plan of operations is not required for activities that would not require a land use permit under AS 38.05 and 11 AAC.

(c) The lessee shall meet with the state annually to discuss lessee's ongoing operations, and any plans for future exploration, development and operation, as such operations or plans relate to the leased or unitized area.

9. PLAN OF EXPLORATION. Within one year after the issuance of this lease, the lessee shall submit to the state for approval a proposed plan of exploration that describes the lessee's plans for exploring the leased area, as set out in 11 AAC 84. No exploration of the leased area may occur until a plan of exploration has been approved by the state.

10. PLAN OF DEVELOPMENT. Before commencing development activities, the lessee shall submit to the state for approval a proposed plan of development that describes the lessee's plans for developing the leased area, as set out in 11 AAC 84. No development of the leased area may occur until a plan of development has been approved by the state. The plan of development shall be submitted by the ninth anniversary of the lease.

11. INFORMATION ACQUIRED FROM OPERATIONS. (a) The lessee shall furnish the state paper and digital copies in a format required by the state of all physical and factual exploration results, logs, surveys and any other derivative data resulting from operations on the leased area, including any surveys, logs, tests or experiments conducted on the leased area by the lessee or by any person or entity acting on behalf of the lessee.

(b) The lessee shall also supply to the state all results, in paper and digital form, for all geological, geophysical, engineering, and geochemical tests, experiments, reports and studies, interpretive or factual, including reservoir studies, profiles, computer modeling work and tests, experiments, reports or studies relating to injection, production testing, or reservoir depletion on the leased area, irrespective of whether the results of such tests, experiments, reports or studies contain sensitive proprietary or confidential information or trade secrets. The lessee shall also file a plat showing the exact location of each well. All of the aforementioned data and results shall be supplied to the state within thirty (30) days of completion of any recorded portion of the operation, test, experiment, report or study from which the data or results are obtained.

(c) Any information filed by the lessee with the state in connection with this lease will be available at all times for the use of the state and its agents and contracting personnel.

12. DIRECTIONAL DRILLING. This lease may be maintained in effect by directional wells whose bottomhole location is within the leased area but that are drilled from locations on lands outside of this lease. In those circumstances, drilling will be considered to have commenced on the leased area when actual drilling is commenced on those other lands for the purpose of directionally drilling into the leased area. Production of geothermal resources from the leased area through any directional well surfaced on those other lands, or drilling or reworking of that directional well, will be considered production or drilling or reworking operations on the leased area for all purposes of this lease. Nothing contained in this paragraph is intended or will be construed as granting to the lessee any interest, license, easement, or other right in or with respect to those lands in addition to any interest, license, easement, or other right that the lessee may have lawfully acquired from the state or from others.

13. DILIGENT AND SAFE DEVELOPMENT AND PREVENTION OF WASTE. (a) All operations on or into the leased area shall be carried on in a safe and workmanlike manner; in compliance with all state, federal, borough or municipal permits and authorizations; in accordance with generally accepted, good engineering practice; with due regard for the protection of life and property, preservation of the environment and conservation of natural resources; and in such a manner as to avoid damage to and waste of geothermal and non-geothermal natural resources. The lessee shall carry out, at the lessee's expense, all orders and requirements of the state relative to the prevention of waste and to the preservation of the leased area. If the lessee fails to carry out these orders, the state will have the right but not the obligation, together with any other available legal recourse, to enter the leased area to repair damage or prevent waste at the lessee's expense.

(b) The lessee shall exercise reasonable diligence as determined by the state in drilling, producing, and operating wells on the leased area unless consent to suspend operations temporarily is granted by the state.

(c) Metering equipment shall be maintained and operated so that it will meet acceptable standards of accuracy in order to measure production from the leased area. Use of such equipment shall be discontinued at any time the state determines that acceptable standards of accuracy are not being maintained. Production shall be stopped until measurement accuracy has been obtained.

(d) Upon development of a geothermal resource on the leased area, the lessee or his agent shall determine whether methods to enhance energy recovery are feasible. The lessee shall conduct studies that evaluate reinjection of spent geothermal liquids, injection of source water or brine for the purpose of energy extraction or means of enhancing energy recovery by improvement of producibility. Results of such evaluations shall be included in the lessee's Plan of Development, and reports, evaluations and conclusions shall be filed with the state.

14. OFFSET WELLS. In the event any well is completed or in commercial production after the effective date of this lease on other than state land, with any part of its producing interval within 1000 feet from the exterior boundary of this lease and within the same geothermal system, or if drainage is a material risk, then the state may notify the lessee in writing to commence drilling an offset well, and within reasonable time, not to exceed 120 days, the lessee shall commence operations for drilling an offset well on the leased area or shall unitize with the well that is draining state land or pay compensatory royalty to the state. An offset well shall mean a well in which the producing interval is situated in the leased area within 1000 feet of the exterior boundary of the lease nearest to the producing interval of the well to be offset. Wells drilled into an approved geothermal unit shall not create an obligation to drill an offset well as to any portion of the leased area that is included within such unit and participating in the revenue.

15. INSPECTION. The lessee shall keep open at all reasonable times, for inspection by any duly authorized representative of the state, the leased area, all wells, improvements, machinery, and fixtures on the leased area, and all reports and records relative to operations, surveys, or investigations on or with regard to the leased area or under this lease. Upon request, the lessee shall furnish the state with copies of and extracts from any such reports and records.

16. UNITIZATION. As provided by law, the lessee may unite with others in collectively adopting and operating under a cooperative or unit agreement for the exploration, development, or operation of the geothermal system or part of the geothermal system that includes or underlies the leased area or any part of the leased area whenever the state determines and certifies that the cooperative or unit agreement is in the public interest.

17. SUSPENSION. The state may from time to time direct or approve in writing suspension of production or other operations under this lease.

18. ASSIGNMENT. This lease, or an interest in this lease, may, with the approval of the state, be assigned, subleased, or otherwise transferred to any person or persons qualified to hold a lease. No assignment, sublease, or other transfer of an interest in this lease, including assignments of working or royalty interests and operating agreements and subleases, will be binding upon the state unless approved by the state. The lessee shall remain liable for all obligations under this lease accruing prior to the approval by the state of any assignment, sublease, or other transfer of an interest in this lease.

19. SURRENDER. The lessee may at any time file with the state a written surrender of all rights under this lease or any portion of the leased area comprising one or more legal subdivisions with the consent of the state. That surrender will be effective as of the date of filing, subject to the continued obligations of the lessee to make payment of all accrued royalties and to place all wells and surface facilities on the surrendered land in condition satisfactory to the state for suspension or abandonment. After that, the lessee will be released from all obligations under this lease with respect to the surrendered lands.

20. TERMINATION FOR DEFAULT. Failure of the lessee to perform timely its obligations under this lease, or the failure of the lessee otherwise to abide by all express and implied provisions of this lease, is a default of the lessee's obligations under this lease. The state may terminate this lease in an administrative proceeding whenever the lessee fails, within 60 days after written notice of that default, to begin and diligently prosecute operations to remedy that default. Failure to submit a plan of exploration or plan of development for approval in a timely fashion may result in termination.

21. RIGHTS UPON TERMINATION. Upon the expiration or earlier termination of this lease as to all or any portion of the leased area, the lessee will be directed in writing by the state and will have the right at any time within a period of one year after the termination, or any extension of that period as may be granted by the state, to remove

from the leased area or portion of the leased area all machinery, equipment, tools, and materials. Upon the expiration of that period or extension of that period and at the option of the state, any machinery, equipment, tools, and materials that the lessee has not removed from the leased area or portion of the leased area become the property of the state or may be removed by the state at the lessee's expense. At the option of the state, all improvements such as roads, pads, and wells must either be abandoned and the sites rehabilitated by the lessee to the satisfaction of the state, or be left intact and the lessee absolved of all further responsibility as to their maintenance, repair, and eventual abandonment and rehabilitation. Subject to the above conditions, the lessee shall deliver up the leased area or those portions of the leased area to the satisfaction of the state.

22. DAMAGES AND INDEMNIFICATION. (a) No rights under this lease may be exercised by the lessee until the lessee has provided to pay the owner of another estate in the land subject to this lease, his lessees and permittees, full payment for all damages that may be sustained by the owner by reason of the exercise of the rights granted by this lease. If the owner for any reason does not settle the damages, the lessee may enter the land after posting a surety bond determined by the state, after notice and an opportunity to be heard, to be sufficient as to form, amount, and security to secure to the owner, his lessees and permittees, payment for damages, and may institute legal proceedings in a court of competent jurisdiction where the land is located to determine the damages which the owner of the land may suffer. The lessee agrees to pay for any damages that may become payable under AS 38.05.130 and to indemnify the state and hold it harmless from and against any claims, demands, liabilities, and expenses arising from or in connection with such damages.

(b) The lessee shall indemnify the state for, and hold it harmless from, any claim, including claims for loss or damage to property or injury to any person caused, directly or indirectly, by or resulting from any act or omission committed under this lease by or on behalf of the lessee. The lessee is not responsible to the state under this subparagraph for any loss, damage, or injury caused by or resulting from the sole negligence of the state.

(c) The lessee acknowledges that the lease is in the vicinity of an active volcano, and that working near a volcano carries inherent risks. The lessee assumes all risks of harm created directly or indirectly by the volcano and shall indemnify the state for, and hold it harmless from, any claims, including claims for loss or damage to property or injury to any person caused, directly or indirectly, by the volcano to lessee or any of lessee’s licensees or invitees.

(d) The lessee expressly waives any defense to an action for breach of a provision of this lease or damages resulting from any harm to the environment that is based on an act or omission committed by an independent contractor in the lessee's employ. The lessee expressly agrees to assume responsibility for all actions of its independent contractors.

23. BONDS. (a) The lessee shall furnish a bond prior to the commencement of lease operations in an amount established by the state and must maintain that bond as long as required by the state.

(b) The state may, after notice to the lessee and a reasonable opportunity to be heard, require a bond in a reasonable amount greater than the amount specified by law where a greater amount is justified by the nature of the surface and its uses, the degree of risk, and the nature of the activity involved in the types of operations being or to be carried out under this lease. A statewide bond will not satisfy any requirement of a bond imposed under this subparagraph, but may be considered by the state in determining the need for and the amount of any additional bond under this subparagraph.

24. AUTHORIZED REPRESENTATIVES. The Director of the Division of Oil and Gas, Department of Natural Resources, State of Alaska, and the person executing this lease on behalf of the lessee shall be authorized representatives for their respective principals for the purposes of administering this lease. The state or the lessee may change the designation of its authorized representative or the address to which notices to that representative are to be sent by a notice given in accordance with Paragraph 25 below. Where activities pursuant to a plan of operations are underway, the lessee shall also designate, pursuant to a notice under Paragraph 25 below, by name, job title, and address, an agent who will be present in the state during all lease activities.

25. NOTICES; PROTEST. (a) Any notices required or permitted under this lease must be by electronic media producing a permanent record or in writing and must be given personally or by registered or certified mail, return receipt requested, addressed as follows:

TO THE STATE:

DIRECTOR, DIVISION OF OIL AND GAS
DEPARTMENT OF NATURAL RESOURCES
550 WEST 7TH AVENUE, SUITE 1100
ANCHORAGE, ALASKA 99501-3560

TO THE LESSEE:

(b) Any notice given under this paragraph will be effective when delivered to the above authorized representative.

(c) A lessee who wishes to protest the amount of money due the state under the lease or any action of the state regarding a provision of this lease must file a written protest with the Division of Oil and Gas within 30 days after the mailing date of the state's notice or bill. A lessee who fails to file a protest within the required time waives any further right to protest. The state will establish the administrative appeal procedure to be followed and will inform the lessee of the procedure no later than 30 days after the filing of the written protest.

26. STATUTES AND REGULATIONS. This lease is subject to all applicable state, federal, borough, and municipal statutes, regulations, and ordinances in effect on the effective date of this lease, and insofar as is constitutionally permissible, to all statutes, regulations and ordinances placed in effect after the effective date of this lease. A reference to a statute or regulation in this lease includes any change in that statute or regulation whether by amendment, repeal and replacement, or other means. This lease does not limit the power of the State of Alaska or the United States of America to enact and enforce legislation or to promulgate and enforce regulations affecting, directly or indirectly, the activities of the lessee or its agents in connection with this lease or the value of the interest held under this lease. In case of conflicting provisions, statutes and regulations take precedence over this lease.

27. INTERPRETATION. This lease is to be interpreted in accordance with the law of the State of Alaska. The paragraph headings are not part of this lease and are inserted only for convenience. The state and the lessee expressly agree that any judicial proceeding affecting this lease shall be conducted in the state Superior Court, Third Judicial District, at Anchorage.

28. INTEREST IN REAL PROPERTY. It is the intention of the parties that the rights granted to the lessee by this lease constitute an interest in real property in the leased area.

29. WAIVER OF CONDITIONS. The state reserves the right to waive any breach of a provision of this lease, but any such waiver extends only to the particular breach so waived and does not limit the rights of the state with respect to any future breach; nor will the waiver of a particular breach prevent termination of this lease for any other cause or for the same cause occurring at another time. Notwithstanding the foregoing, the state will not be deemed to have waived a provision of this lease unless it does so in writing.

30. SEVERABILITY. If it is finally determined in a judicial proceeding that any provision of this lease is invalid, the state and the lessee may jointly agree by a written amendment to this lease that, in consideration of the provisions in that written amendment, the invalid portion will be treated as severed from this lease and that the remainder of this lease, as amended, will remain in effect.

31. CONDITIONAL LEASE. If all or a part of the leased area is land that has been selected by the State of Alaska under laws of the United States granting lands to the State of Alaska, but the land has not been patented to the State of Alaska by the United States, then this lease is a conditional lease as provided by law until the patent becomes effective. If for any reason the selection is not finally approved, or the patent does not become effective, any rental, royalty, or other production or profit-based payments made to the state under this lease will not be refunded.

32. NONDISCRIMINATION. The lessee and the lessee's contractors and subcontractors may not unlawfully discriminate against any employee or applicant for employment.

33. ROYALTY ON PRODUCTION. (a) The state's royalty share of production from the lease is not subject to lien and shall be paid to the state, free and clear of all costs including costs incurred for exploration, production, transmission, or transportation, and regardless of whether the costs are incurred on or off the lease.

(b) The lessee shall pay to the state a royalty of 1.75 percent in amount or value of:

(1) the gross revenues derived from the production, sale, or use of geothermal resources from the leased area during the first 10 years immediately following the date the geothermal resource first generates gross income and 3.5 percent of the gross revenues derived from the production, sale, or use of geothermal resources under the lease after that first 10-year period;

(2) the market value of the geothermal resources that are sold in other than a bona fide arm's length transaction between independent parties; and

(3) the market value of the geothermal resources consumed by the lessee.

(c) The state may adjust the royalty rates set out in subparagraph (b) above 20 years after the commencement of commercial production, and at intervals of not less than 10 years thereafter.

(d) With each production royalty payment, lessee shall submit to the state a statement of the geothermal resources produced, processed, used, shipped, or sold, including geothermal resources converted to other forms of energy, together with the price obtained or, where the substances are used without sale, an accounting of the alternate uses of the energy with evidence of their fair market value, and such other information relating to valuation as the state may require.

34. ROYALTY IN VALUE. Except as provided in Paragraph 35, all royalties are to be paid to the state in value. All royalty payable in value to the state must be paid on or before the last federal banking day of the calendar month following the month in which the geothermal resources are produced. The amount of all royalty in value payments which are not paid when due under this lease or which are subsequently determined to be due to the state as the result of a redetermination will bear interest from the last federal banking day of the calendar month following the month in which the geothermal resources were produced, until the obligation is paid in full. Interest shall accrue at the rate provided by law.

35. ROYALTY IN KIND. (a) At the state's option, which may be exercised from time to time upon not less than 90 days notice to the lessee, the lessee must deliver all or a portion of the state's royalty due under this lease in kind. Delivery must be on the leased area or at a place mutually agreed to by the state and the lessee, and must be delivered to the State of Alaska or to any individual, firm, or corporation designated by the state.

(b) Royalty geothermal resources taken in kind must be delivered in merchantable condition.

(c) After having given notice of its intention to take, or after having taken its royalty on geothermal resources in kind, the state, at its option and upon 90 days notice to the lessee, may elect to receive a different portion or none of its royalty in kind. If, under federal regulations, the taking of royalty geothermal resources in value by the state creates a supplier-purchaser relationship, the lessee hereby waives its right to continue to receive royalty geothermal resources under the relationship, and further agrees that it will require any purchasers of the royalty geothermal resources likewise to waive any supplier-purchaser rights.

(d) If a state royalty purchaser refuses or for any reason fails to take delivery of geothermal resources, or in an emergency, and with as much notice to the lessee as is practical or reasonable under the circumstances, the state may elect without penalty to underlift for up to 180 days all or a portion of the state's royalty on geothermal resources produced from the leased or unit area and taken in kind. The state's right to underlift is limited to the portion of royalty geothermal resources that the royalty purchaser refused or failed to take delivery of, or the portion necessary to meet the emergency condition. Underlifted geothermal resources may be recovered by the state at a daily rate not to exceed ten (10) percent of its royalty interest share of daily production at the time of the underlift recovery.

36. REDUCTION OF RENTAL AND ROYALTY. The state may, after public hearing, reduce the lessee's obligation to pay royalty on all of the leased area or on any tract or portion of the leased area segregated for royalty purposes whenever the state determines that it is necessary to do so to promote development, or that the lease cannot be successfully operated under its terms. The state may also waive, suspend, refund or reduce the rental on all or any portion of the leased area in accordance with the applicable statutes and regulations.

37. BINDING EFFECT. The state and the lessee agree that this lease, including all attachments and documents that are incorporated in this lease by reference, contains the entire agreement between the parties, and each of the covenants and conditions in this lease including any attachments will be binding upon the parties and upon their respective heirs, administrators, successors and assigns.

38. DEFINITIONS. All words and phrases used in this lease are to be interpreted where possible in the manner required in respect to the interpretation of statutes by AS 01.10.040 and AS 01.10.050. However, the following words have the following meanings unless the context unavoidably requires otherwise:

(1) "drilling" means the act of boring a hole to reach a proposed bottom hole location through which geothermal resources may be produced;

(2) "force majeure" means war, riots, act of God, unusually severe weather, or other acts of nature.

(3) "geothermal system" means a stratum, pool, reservoir, or other geologic formation containing geothermal resources;

(4) “commercial production” means production of geothermal resources in quantities sufficient to yield a return in excess of operating costs, even if drilling and equipment costs may never be repaid and the undertaking considered as a whole may ultimately result in a loss.

39. EFFECTIVE DATE. This lease takes effect on _____.

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BY SIGNING THIS LEASE, the state, as lessor, and the lessee agree to be bound by its provisions.

STATE OF ALASKA

By: _____
W.C. Barron
Director, Division of Oil and Gas

STATE OF ALASKA )
) ss.
Third Judicial District )

This is to certify that on _____ before me appeared _____, of the Division of Oil and Gas of the State of Alaska, Department of Natural Resources, and who executed this lease and acknowledge voluntarily signing it on behalf of the State of Alaska as lessor.

_____
Notary public in and for the State of Alaska
My commission expires_____

LESSEE _____

Signature _____

Printed Name/Title _____

INSERT NOTARY AND ACKNOWLEDGEMENT STATEMENT OF LESSEES HERE.