Chapter Three: Description of the License Area

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Chapter Three: Description of the License Area

AS 38.05.035(g)(1)(B)(i) requires that the Director consider and discuss the property descriptions and locations of the license area. The following overview includes information material to the determination of whether the exploration license will be in the state's best interest (AS 38.05.035(e)(1)(B)(iii)). It is not intended to be all inclusive.

A. Property Description

The Southwest Cook Inlet license area consists of approximately 169,000 acres on and around the Iniskin Peninsula, Iniskin Bay, Oil Bay, Chinitna Bay and the adjacent state-owned waters seaward to three nautical miles from the coastline. The exploration license area consists of state-owned, unencumbered lands within T. 3 S., R. 20-22 W., T. 4 S., R. 20-23 W., T. 5 S., R. 21-24 W., T. 6 S., R. 22-25 W., T. 7 S., R. 23-25 W., Seward Meridian (Figure 3.1). The solicitation area contains not only State, but also federal, and privately owned land, and State owned waters of Cook Inlet. It is located within the Kenai Peninsula Borough. The exploration license area is located within the solicitation area that was identified in the May 30, 2013 Notice of Intent to Evaluate the Oil and Gas License Proposal soliciting public comment and competing proposals.

The exploration license area includes state-selected but unconveyed acreage, which cannot be included in an exploration license until the state receives title. It is possible, during the term of the license, that some of the acreage on which the state has topfiled or the mineral estate of the Native selected land or Native allotments may be conveyed to the state. The successful licensee may request to have the selected acreage identified in its application included or excluded in the issued license.

The majority of the on-shore land within the license area is Cook Inlet Regional Inc. (CIRI) property. CIRI owns the subsurface estate and the surface estate is owned by several village corporations including Chickaloon, Knik, Ninilchik, Salamatof, Seldovia, and Tyonek (CIRI 2014b). The northeast portion of the license area is adjacent to Lake Clark National Park and the Alaska Maritime National Wildlife Refuge along the north shore of Chinitna Bay. The tidelands in and adjacent to Lake Clark National Park and the Alaska Maritime National Wildlife Refuge have been designated as Special Use Lands (ADL 227835) (DNR 2001). The federal and privately owned land is outside the state's jurisdiction with regards to access and management of the subsurface mineral estate.

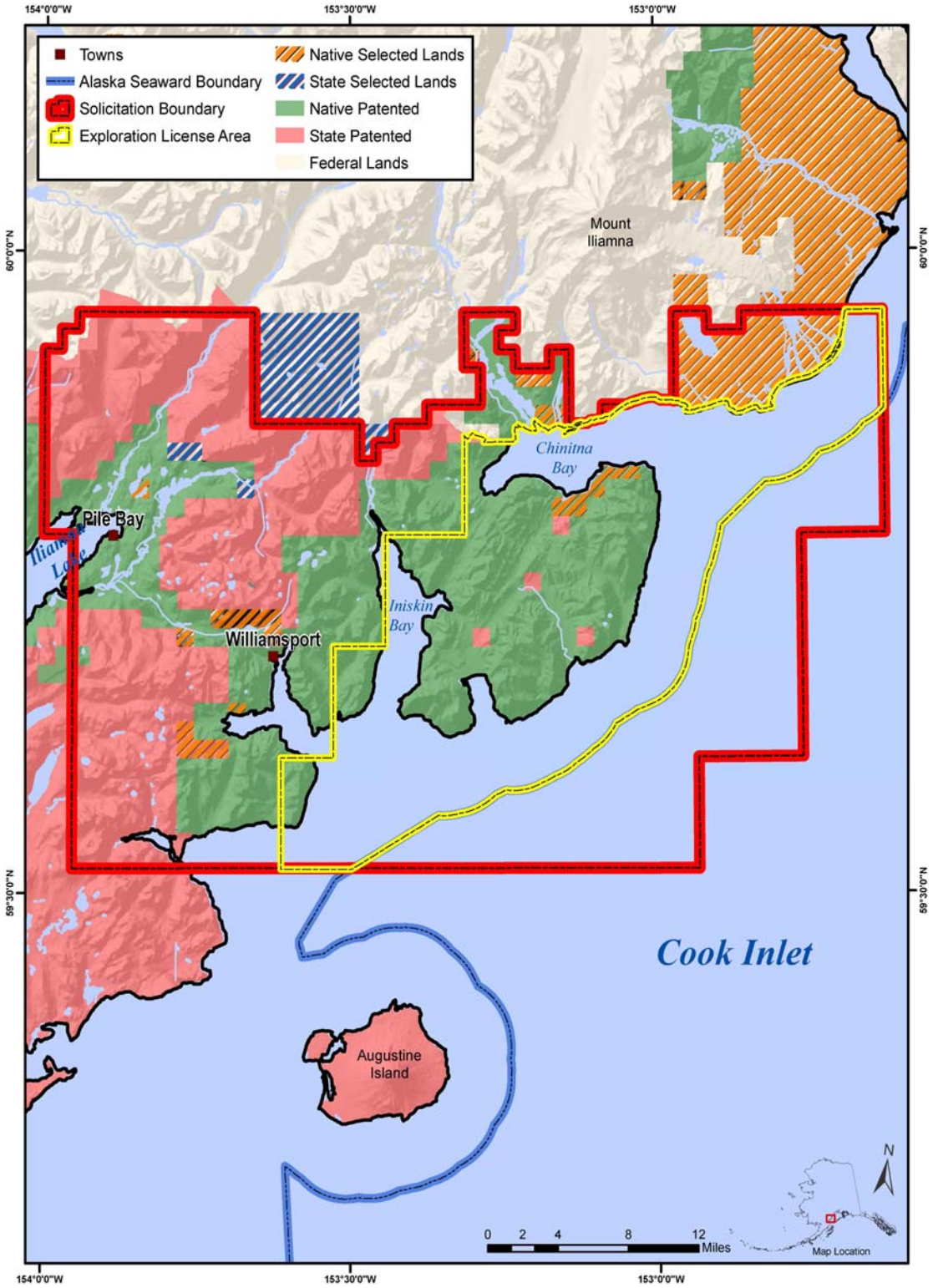

Figure 3.1. Location and boundaries of the Southwest Cook Inlet exploration solicitation and license area.

B. Access

The primary access routes within the license area are by marine transport, helicopter, and ancillary roads and trails on state and private property. Marine facilities in Cook Inlet would provide ports of call for vessel traffic to, from, and through the license area. The closest port facilities are shallow-draft navigation ports, Williamsport and Port Graham, and deep-draft navigation at Port of Homer, City of Seldovia, with other deep-draft facilities available in middle and upper Cook Inlet (Cape International 2012).

Cook Inlet waters host high volume vessel traffic. Approximately 480 vessel trips for self-propelled vessels greater than 300 gross tons entered Cook Inlet in 2010. Levels of activity varied, with Kachemak Bay in lower Cook Inlet experiencing the highest levels of traffic in Cook Inlet. Vessel traffic is forecasted to remain flat or show moderate increases due to population growth and post-recession improvements in the economy (Cape International 2012).

Williamsport is the closest permanent port facility and is just outside of the license area to the west. It is privately owned, and is the connection port with the state road that connects Iliamna Bay to Lake Iliamna, and the Village of Pile Bay. The road shortens the 1,100-mile marine route from Cook Inlet to Bristol Bay. Cargo, fishing boats, and vehicle traffic are transported to and from Cook Inlet to the Lake Iliamna area, with high volume use reported in summer months (Cape International 2012). Lake Iliamna drains west to Bristol Bay, and cargo can be transported from Cook Inlet Basin to Bristol Bay and into the Bering Sea ocean waters beyond by way of the road. Vessel traffic into and from Williamsport is planned based upon the 14.5 foot daily tidal range, and high tides of 20 feet are preferred for barge traffic (USDC 2006). There are no additional small-boat harbor facilities in the area (Waring 2010).

The road from Williamsport northwest to Pile Bay Village on Lake Iliamna, is a single lane unpaved state owned and maintained road that supports local and commercial traffic. It is known as Pile Bay-Williamsport Road, or Portage Road, is 15.5 miles long, and has was constructed the 1930s. This route has been in use by residents and travelers for hundreds of years (USACE 1995). It occupies a 100 foot wide right of way (ROW), and provides a portage connection across the Chigmit Mountains (USACE 2007). It is usually open from June through November, weather permitting, and is not maintained in winter (Waring 2010).

Approximately half the Pile Bay-Williamsport Road is in the Kenai Peninsula Borough, with the remainder in the Lake and Peninsula Borough (USACE 2007). A six-mile segment was repaired in 2009 for improved safety (Klouda 2010). The current terminus of the Pile Bay-Williamsport Road is on private property at Lake Iliamna (Waring 2010).

Several historic Revised Statute (RS) 2477 ROW trails are located on the Iniskin Peninsula. RS 2477 is found in section 8 of the Mining Law of 1866. RS 2477 was enacted by the US Congress in 1866 to encourage the settlement of the Western United States by the development of a system of highways. The term RS 2477 is used to describe a public ROW across unreserved federal land to guarantee access across federal land, and is transferred with the lands to subsequent State or private ownership. The revised statute trail (RST) 496, Iniskin Peninsula Road, runs from Camp Point near Seal Spit on Chinitna Bay along Fritz Creek Valley for about eight miles. The RST 529, the Iniskin Bay-Oil Bay Trail, runs approximately 2.5 miles from Oil Bay to an historic oil drilling site abandoned over a century ago. The RST 1873, Dry Bay Trail, is a trail that extends from Dry Bay inland for approximately 2.5 miles. Another 5 mile trail, RST 311, traverses over Portage Pass from Chinitna Bay to Iniskin Bay (Waring 2010). These roads and trails are shown on Figure 6.1.

C. Subsurface Property and the Public Interest

The Statehood Act allowed Alaska to select 104 million acres of federal land as its economic base. The land grants included the subsurface mineral rights underlying these selections. The Act requires the state to retain these mineral interests when conveying interests in the surface estate stating "mineral deposits in such lands shall be subject to lease by the State as the State legislature may direct" (P.L. 85-508, § 6(i)).[1] Additionally, the Act states that if Alaska disposes of its mineral estate contrary to the Act, it will have to forfeit that mineral estate to the federal government.

Complying with the intent of the Act, the Alaska Constitution directs the state's policy: "to encourage ... the development of its resources by making them available for maximum use consistent with the public interest" and 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, art. VIII, §§ 1, 2.)

To meet this mandate, the legislature enacted Title 38 of the Alaska statutes and directed DNR to implement these laws. The legislature found the people of Alaska have an interest in developing the state's oil and gas resources and maximizing the economic and physical recovery of those resources (AS 38.05.180(a)). When state surface land is conveyed to an individual citizen, state law requires that the deed reserve mineral rights for the state (AS 38.05.125).

A large portion of the state owned lands within the license area are designated Alaska's School Trust. DNR Department Order 143 states that if School Trust Lands are involved, the following criteria must be met prior to the disposal of the land or resources:

- The action approved must be for full, fair market value at the highest and best use of the parcel, or
- The action must be a result of an existing contractual obligation (i.e., land sale contract, reappraisal of an existing lease, or a land settlement with a municipality).

D. Historical Background

At the time of first European contact, Dena'ina Athabaskans occupied all of Cook Inlet north of Kamishak Bay. Na-Dene speaking Athabaskans were well established in the region by 1000 AD, replacing an earlier Kachemak Tradition culture. The Kachemak were Yu'piq speaking marine specialists descendent of Aluutiq or Yupik cultures of the Kodiak Archipeligo and/or Southwest Alaska. The earliest Kachemak Tradition sites date to ca. 3000 BC and are found in Kachemak Bay and coastal margins of Cook Inlet (Boraas 2007). Evidence of earlier Northern Archaic and American Paleoarctic cultures have also been identified, however most occur at inland locations such as Round Mountain, Long Lake, Trapper Creek (Reger 2004; Wygal 2009).

The Dena'ina have a long history of fishing, hunting, and gathering in the license area. Traditional subsistence resources include anadromous and pelagic fish, beluga whales, waterfowl, seals, moose, sheep, fur bearers, and plants (Fall 1981).The Dena'ina were salmon fishing specialists and employed weirs, nets, and complex storage pits (caches) to preserve their harvests (Boraas 2007). Winter homes were of permanent semi-subterranean design and were common throughout Cook Inlet (Reger 2004).

Euroamerican activity in the region began in the late eighteenth century with the arrival of Russian fur traders and other European explorers. Russian trading posts were established at over a dozen locations

[1] There are two types of interests or ownership in land: the surface estate and the subsurface or mineral estate. The interests may become separated when an original owner keeps only the surface estate and sells the subsurface, or when an owner sells only the surface and keeps the subsurface to sell or use later. Therefore, the surface and subsurface interests may be separate, and a property or homebuyer could buy land but acquire only the surface estate.

from Cook Inlet to Prince William Sound. The first known trading post at Illiamna Lake was established by the Lebedef-Lastochkin Company in the 1790s (Townsend 1961). The fur trade generally continued unimpeded after the Alaska Purchase of 1867.

Rapid change occurred in the ensuing decades with discovery of gold at Turnagain Arm (1896), commercial fishing and canneries, oil and gas exploration, missionization, schools, and establishment of a cash economy and permanent towns and cities. Throughout this period the Dena'ina experienced epidemic disease, hunting, fishing, and land inequities, and major culture change (Boraas 2007).

E. Local Communities

There are no communities within the license area, though it is entirely within the boundary of the Kenai Peninsula Borough. In 2012, the United States Census Bureau estimated that the population of the Kenai Peninsula Borough was 56,900 people (USCB 2014). The larger communities in the borough include Homer, Kenai, Soldotna, and Nikiski.

In 2010, the estimated unemployed adults living in the Kenai Peninsula Borough was 8.4%. The 2010 estimated population living below the poverty line in the Kenai Peninsula Borough was 9.12% (ADCRA 2014). Table 3.1 provides additional information on the region's employment and income statistics.

Table 3.1. Socioeconomic indicators for communities near the license area.

Community	Population	Estimated Median Household Income ($)	Estimated in Labor Force (#)	Estimated Unemployed (%)	Estimated Population Living Below Poverty Level (%)
Kenai Peninsula Borough	55,400	59,421	24,089	8.4	9.12
Tyonek	171	38,125	88	14.04	30.24
Anchor Point	1,930	49,712	823	7.72	10.21
Homer	5,003	52,535	2,136	3.23	10.59

Notes: Values are from 2010 census.

Source: ADCRA 2014; USCB 2014

The nearest development to the license area is Williamsport, which is not a population center, but a shallow draft port and the end of the portage road between Cook Inlet and Lake Iliamna. The closest community to the license area is Pile Bay which is at the other end of the Portage road that begins in Williamsport. The closest population center and community in the Cook Inlet basin is Anchor Point which is located approximately 60 miles east of the license area, on the east side of Cook Inlet on the road system. Anchor Point has a population of 1,930 people (USCB 2014). Tyonek, which is located approximately 120 miles north of the license area's northern boundary, is the closest community on the western shore of Cook Inlet with a population of 171 (USCB 2014). There are several other communities that are located on Lake Iliamna, close to the license area, including Pile Bay, Pedro Bay, Iliamna, Newhalen, and Nondalton. These communities are on the opposite side of the Chigmit Mountains in the Aleutian Range and are part of the Bristol Bay watershed and not likely impacted by activity in this license area.

No population information is available from the U.S. Census Bureau regarding the populations of Pile Bay or Williamsport. Both of these settlements have important infrastructure supporting the transportation of boats, fuel, and other supplies into the Lake and Peninsula Borough and the Bristol Bay region (USACE 2007).

1. Pedro Bay

The village is located on the northeast shore of Iliamna Lake, about 175 miles southwest of Anchorage. Iliamna Lake is the largest lake in Alaska, measuring about 80 miles long and 20 miles wide. The subsistence fishing and hunting culture is the predominant lifestyle. The Pedro Bay Village Tribal Council is active throughout the year, and the population is 42 year round residents, with 67% of Dena'ina (Tanaina) descent (DCCED 2014). It covers about 18 mi^2 of land and 9 mi^2 of water. An overland trail connects the communities of Pile Bay and Pedro Bay.

2. Tyonek

The village is located on the west shore of Cook Inlet approximately 70 miles southwest of Anchorage and approximately 120 miles north of the license area. The subsistence fishing and hunting culture is the predominant lifestyle (DCCED 2014). The population is 171 year round residents made up of approximately 95% Alaska Native of Dena'ina Athabascan descent. The Native Village of Tyonek is a federally recognized tribe that governs the village (DCCED 2014). Eighty-eight of the residents were employed in 2012, 45 of which were employed by local government and the other 43 were employed in the private sector, predominantly in construction (DOLWD 2014).

3. Anchor Point

The town of Anchor Point is located on the Kenai Peninsula within the Kenai Peninsula Borough at the junction of the Anchor River and its north fork at mile 156 of the Sterling Highway. Anchor Point has a visitor's center and a chamber of commerce. The year round population is 2,041 people (DCCED 2014). The economy is relatively diverse with approximately 21% of the working population employed in trade, transportation, and utilities and nearly 18% of the working population employed by local governmental organizations (DOLWD 2014).

4. Homer

Homer is a First Class City within the Kenai Peninsula Borough. It is located on the north shore of Kachemak Bay on the southwestern edge of the Kenai Peninsula. It includes the Homer Spit which is a 4.5 mile glacial moraine gravel bar. The City of Homer comprises 10.6 mi^2 of land and 14.9 mi^2 of water. There are 5,136 year round residents. The Homer area has been home to the Kenaitze for thousands of years (DCCED 2104).

Various coal mining operations have been conducted in and around the area. Commercial and sport fishing are important to the local economy and tourism has been gaining importance in the economy. Homer is the gateway to destinations in Kachemak Bay and also a terminus for the Alaska Marine Highway System to embark to Kodiak or out to the Aleutian Chain (DCCED 2104). Homer has a diverse economy with 2,136 people employed with 23.2% in the trade, transportation and utilities sector; 17.9% employed by local government; 15.9% in leisure and hospitality; and 12.2% in education and health services (DOLWD 2014). Homer is the nearest deep-water port to the project area.

5. Seldovia

Seldovia is a First Class City within the Kenai Peninsula Borough. It is located on the south shore of Kachemak Bay. The city comprises 0.4 mi^2 of land and 0.2 mi^2 of water. Seldovia is an Alutiiq village, and commercial fishing and subsistence are the basis for the local economy and culture. There are 245 year round residents (DCCED 2014.). Seldovia is the second closest deep water port to the license area. The economy of Seldovia consists of 103 employed residents with approximately 15% of the working population employed in trade, transportation and utilities and nearly 49% of the working population employed by local governmental organizations (DOLWD 2014).

6. Kenai

Kenai is a first class city in the Kenai Peninsula Borough. It is located on the western coast of the Kenai Peninsula at the mouth of the Kenai River and on Cook Inlet. It is situated on the western boundary of the Kenai National Wildlife Refuge on the Kenai Spur Highway. Kenai's population is 7,247 year round residents (DCCED 2014). The Kenai River is a major sport fishing location for Anchorage residents and tourists, as the river is world-renowned for trophy Chinook and silver salmon (DCCED 2014). Kenai's economy consists of 3,532 employed residents with 20.2% of the working population in trade, transportation and utilities; 15.4% in education and health services; 14.3% in natural resources and mining; 11.7% of the working population employed by local governmental organizations; and 10.9% in leisure and hospitality (DOLWD 2014).

7. Nikiski

Nikiski is an unincorporated town in the Kenai Peninsula Borough. It is located on the Kenai Peninsula, nine miles north of the City of Kenai, and also known as Port Nikiski. Nikiski's population is 4,593 year round residents. Nikiski grew with the discovery of oil in 1957 on the Kenai Peninsula and has served as an oil field services base supporting oil production and exploration in Cook Inlet (DCCED 2014). The economy of Nikiski consists of 1,980 employed residents with 19.2% of the working population in natural resources and mining; 16.5% of the working population in trade, transportation and utilities; 13% of the working population employed by local governmental organizations; 12.7% in education and health services; and 9.2% in leisure and hospitality (DOLWD 2014).

F. Historical and Cultural Resources

The National Historic Preservation Act of 1966 created the State Historic Preservation Office (SHPO). The Alaska Office of History and Archaeology (OHA) carries out the responsibilities of SHPO. SHPO responsibilities include (DNR 2013):

- Review and consultation under Section 106 of the National Historic Preservation Act (NHPA)and the Alaska Historic Preservation Act;
- Statewide historic preservation planning (Alaska's Historic Preservation Plan);
- Statewide historic property survey and inventory (Alaska Heritage Resources Survey);
- National Register of Historic Places property nomination;
- Federal historic preservation grants-in-aid program administration;
- Historic preservation program development assistance and national program participation certification for local governments (Alaska's Certified Local Government Program); and,
- Federal, state, and local historic preservation project advisement and assistance

Historic and cultural resources can include a range of sites, deposits, structures, ruins, buildings, graves, artifacts, fossils, and objects of antiquity. The lead agency, determined to be the federal agency with the most authority over a project, is required to review the project and consult with the appropriate parties under either Section 106 of the NHPA (for Federal undertakings) or the Alaska Historic Preservation Act (for State undertakings) to assess the potential for effects to significant cultural resources.

The first comprehensive archaeological survey of Cook Inlet was conducted in 1930 by Frederica de Laguna (1975). Seminal ethnographic and linguistic studies were conducted by Osgood (1937),

Townsend (1965), Kari and Fall (2003), and Kari (2007). A summary of over 20 years of ethnographic studies in Lake Clark National Park and Preserve was recently compiled by Gaul (2007).

Large-scale excavations by Townsend (1961) at Pedro Bay provided evidence of Eskimo, Athabaskan, Russian-American, and Euroamerican use of Illiamna Lake. Work at the Chinitna Bay pictograph site (SEL-006) located at Ocean Bay (Kachemak) component was similar to the Pedro Bay site (Townsend 1969).

Most archaeological surveys of the past decades were conducted to meet requirements of Sections 106 and 110 of the National Historic Preservation Act (NHPA), Section 14(h)(1) of the Alaska Native Claims Settlement Act , and the Alaska Historic Preservation Act (AS 41.35). In 1975 CIRI completed a regional inventory of Section 14(h)(1) sites (Brelsford 1975). Major oil and gas-related surveys were conducted by Mobley and Carlson (1982), Mobley and Mobley (2012), and HDR (2013). Lands associated with the Chuitna coal deposits were inspected by Gerlach and Lobdell (1984), Lobdell (1988), and most recently SRBA (2006, 2009). Studies of the Cook Inlet side of Lake Clark National Park and Preserve (LACL) include a coastal survey between Chinitna and Tuxedni Bay (Klingler and Reger 1993), the Chinitna Bay coastline (Tennessen 2006), and Kamishak Bay (Reger 1980). The Williamsport-Pile Bay Road was surveyed by DePew (2001). Substantial surveys are currently underway in association with the copper and gold Pebble project. Field surveys were conducted within the license area in 2005 and 2007. There are 11 Alaska Heritage Resource Survey sites in the license area near Knoll Head, Oil Bay, Chinitna Point, and the northern shore of Chinitna Bay. None of these have been evaluated for the National Register of Historic Places (Braund 2011).

Artifacts recovered on state land belong to the state and are curated in state facilities. These artifacts can be loaned to groups who have appropriate curation and exhibit facilities (AS 41.35.020(b)).

G. Climate

The Cook Inlet area is characterized by three climate zones: the maritime zone, continental zone, and transition zone. In the maritime zone areas, which encompass the coast and islands, annual precipitation averages about 60 inches. Mean maximum temperatures in the summer are in the upper 50s, and low means during winter are in the low 20s. Offshore winds average 12-18 knots, with winter extremes of 50-75 knots. Areas further from the coast may have continental zone characteristics, with annual precipitation from 20 inches, with January temperatures ranging from 4-22°F and July temperatures ranging from 46-65°F (DCCED 2014). Surface winds tend to be lighter compared to coastal maritime areas (BLM 2008).

Temperature and precipitation records from the last half of the twentieth century show annual and seasonal mean temperature increases throughout Alaska (Stafford et al. 2000). The average temperature increase in Alaska from 1949 to 2009 was 3.0°F, although the temperature changes varied greatly across the state. Most of the change occurred in winter and spring months. The fall months showed the least amount of change (ACRC 2014). Global surface temperatures have increased about 0.9°F since the late 19th century. Since 1900 the increase was 0.09°F per decade, and was about 0.29°F per decade during the past 30 years (Folland et al. 2006).

At northern latitudes, potential effects of climate change may include rising temperatures, melting glaciers, and a reduction in seasonal sea ice cover. These changes could result in increased storm effects and higher coastal erosion rates, increased permafrost melting, shifting vegetation zones, increased fires, insect outbreaks, changing animal migration paths, and changing subsistence patterns. Climate changes and associated geologic hazards may threaten and negatively impact Alaskans and other users of the Arctic (DGGS 2014).

In 2006, the Alaska Climate Impact Assessment Commission (ACIAC) was formed to assess the effects of climate change on citizens, resources, economy, and assets of the State of Alaska (ACIAC 2008). In September 2007, Administrative Order 238 was signed, creating the Climate Sub-Cabinet. Members of the sub-cabinet represent the Alaska DEC, DF&G, DNR, Department of Transportation (DOT), Department of Commerce, Community, and Economic Development (DCCED), University of Alaska, and the Office of the Governor. The sub-cabinet was tasked with developing an Alaska Climate Change Strategy, providing assessments and recommendations for adaptation, mitigation, and for defining research needs to assist Alaskans with the impacts of climate change. The strategy serves as a guide for responding to climate change, identifying immediate priorities, long-term strategies, and including recommendations for saving energy and reducing greenhouse gas emissions. Dillingham, Clark's Point, and Port Heiden are three of the 31 Alaskan villages threatened by coastline impacts (Alaska Climate Sub-Cabinet 2009).

In April 2008, the Governor's sub-cabinet released its report of recommended actions including emergency planning and training, erosion control, and village relocation planning (IAW 2008). In 2009-2010, the ACIAC released two draft and two final reports written by the Climate Change Advisory Groups. The Adaptation Advisory Group's report discussed how to address present and future impacts on infrastructure, human health, and ecosystems. Current impacts are those associated with village relocation in Western Alaska, though climate change affects all of the state. The Mitigation Advisory Group focused on preparing recommendations to be included in a strategy to mitigate greenhouse gas emissions in Alaska. One section of the report looks at the oil and gas industry. The Mitigation Advisory Group's recommendations may be beneficial to possible future development (ACIAC 2012).

H. Geologic Hazards

The natural environments in the license area include estuarine, mountain, forest, marsh, and riverine (Fall 1981). The primary geologic hazards within the license area include earthquakes and faulting, volcanoes and associated hazards, and tsunamis. These geologic hazards could impose constraints to exploration, development, production, and transportation activities.

1. Earthquakes and Faulting

The license area is vulnerable to naturally occurring subduction zone earthquakes that are 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. Earthquakes can occur along the subduction interface, within the shallow crustal region of the upper plate, and within the Benioff Zone at great depth. Volcanoes, such as Augustine Island and those located on the Aleutian Islands, are a direct result of the subduction process. In addition to surface fault rupture and strong ground shaking, earthquakes can cause other events such as landslides, avalanches, tsunamis, uplift, subsidence, infrastructure failures, and soil liquefaction (DHSEM 2013).

Two significant earthquakes have been observed in the license area in in the last 100 years. The first was recorded on November 10, 1938 with an estimated magnitude of 8.3. Its epicenter was located in the Gulf of Alaska near the Shumigan Islands (Caldwell et al. 2012). The second major earthquake occurred on March 27, 1964, also known as the Good Friday Earthquake.

The 1964 earthquake occurred along the Aleutian Arc, which is the northern rim of the circum-Pacific Ring of Fire zone of seismic and volcanic activity where the Pacific Plate subducts into the mantle beneath North America (USGS 2014e). The majority of the seismicity in the arc area comes from coupling along the thrust fault interface, or the megathrust zone. The 1964 earthquake rupture began at 35 kilometers depth in the northern part of Prince William Sound, and it traveled southwest across the

Kenai Peninsula to the western part of Kodiak Island (Ichinose et al. 2007). The epicenter was 120 kilometers southeast of Anchorage (USGS 2014d).

The earthquake was the largest recorded in North America during the past century (Doser & Brown 2001). With a moment magnitude of 9.2, it was also the second-largest earthquake recorded in the world since 1900 (USGS 2014e). The event caused significant tectonic deformation. Upper Cook Inlet land subsided, and that around Prince William Sound was uplifted (Hamilton et al. 2005). Vertical land displacement, over 520,000 square kilometers, ranged from 11.5-meter uplift to 2.3-meter subsidence relative to sea level (USGS 2014d).

Shaking during the earthquake is believed to have lasted for three minutes (USGS 2014d). Thousands of aftershocks followed the main shock, and they occurred over a belt 250 kilometers wide and 800 kilometers long. Eleven of the aftershocks that occurred within 24 hours of the main shock had magnitudes of 6.0 or greater (AEIC 2014). The earthquake caused 128 deaths and $311 million in property damage. Various communities, ranging geographically from Chitina to Kodiak, felt strong effects. Much of the loss of life came not from the ground shaking but from the tsunamis that the earthquake generated. Tsunamis inundated multiple towns around the Gulf of Alaska and in Canada, Hawaii, and the western coast of the United States. The largest wave amplitude recorded was 67 meters in Valdez Inlet (USGS 2014d). In some towns, landslides triggered local tsunamis (AEIC 2014).

Damages reported from the license area and surrounding communities were relatively minor. The community of Tyonek and the southwest shore of Cook Inlet reported no casualties and minor damages. One waterline buried eight feet below ground surface was broken by ground fissures. South of Tuxedni Bay the roof of a small sawmill collapsed forcing it out of operation. This was the most significant damage in the vicinity of the license area (Plafker 1969b).

2. Volcanoes

There are four historically active volcanoes in the Cook Inlet region that may pose hazards to the license area: Spurr, Redoubt, Iliamna, and Augustine. Redoubt and Spurr are to the north of the license area and ash fall from these volcanoes has potential to impact this region, depending on wind direction. Redoubt Volcano has produced significant ash eruptions in recent years including 1966-68, 1989-90, and 2009. Mount Spurr, located in the Tordrillo Mountains, last erupted explosively in 1992. Iliamna Volcano is also located north of the license area, although large ash eruptions have not been recorded in historical time. Hazards associated with Iliamna such as debris flows, pyroclastic flows, and volcanic mudflows (lahars) are mostly confined to the flanks of the volcano and major drainages that extend from the summit. In the license area, the hazard zones for lahars and pyroclastic flows include West Glacier Creek (flows into Chinitna Bay), and Red River and Johnson River (flowing into Cook Inlet) (Waythomas and Miller 1999).

Augustine Volcano is the most active volcano in Cook Inlet and presents several potential geologic hazards to the license area and surrounding waters (Power et al. 2010; Waythomas and Waitt 1998). It is located about 10 miles south of the license area's southern boundary. Hazardous phenomena recorded at Augustine Island include volcanic ash clouds, ash fallout, volcanic bombs, pyroclastic flows, debris avalanches, lahars, floods, lava flows, volcanic gases, and tsunamis (Waythomas and Waitt 1998). Augustine Volcano has experienced several major eruptions in historical time, such as eruptions in 1883, 1935, 1963-64, 1976, 1986, and December 2005 through 2006 (Waitt and Begét 2009). The most recent explosive eruption occurred in 2006, after approximately 6 months of precursory activity (Coombs et al. 2010).

3. Volcanic Ash Clouds, Ash Fallout and Volcanic Bombs

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 as inhaling volcanic ash can cause respiratory issues and may significantly decrease visibility (Waythomas and Waitt 1998). Ash is extremely abrasive, mildly corrosive, and electrically conductive, especially when wet (USGS 2014c).

Historically, Augustine Volcano has erupted explosively, sometimes ejecting fragments of tephra into the atmosphere. Larger-sized volcanic debris, called blocks or bombs, typically strike near the vent of the volcano. 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 Augustine eruptions reached altitudes higher than 40,000 feet in height. 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 Anchorage airport, but landed safely, and air traffic was routed around the ash cloud for several days (Waythomas and Waitt 1998).

The 2006 Augustine eruption included pyroclastic flows, lava flows, block- and ash-flows, lava domes, and ash fall deposits (Coombs et al. 2010). The bulk of the ash from this eruption fell into Cook Inlet, with minor amounts of ash (≤1mm) falling on villages and towns in the lower Cook Inlet (Power et al. 2010).

4. Pyroclastic Flows and Debris Avalanches

A pyroclastic flow is a fast-moving mixture of hot ash, pumice, rock fragments, and volcanic gas that flows downslope during eruptive events. Pyroclastic flows may result from explosive eruptions or the collapse of a lava dome; as the lava dome cools, it may collapse and fall apart, moving debris downslope several miles beyond the vent (Waythomas and Waitt 1998; USGS 2014a). A debris avalanche is the rapid downslope movement of rock, volcanic debris, snow, or ice. Debris avalanches are not always associated with eruptive events. Heavy rainfall, the intrusion of magma, and earthquakes can cause catastrophic avalanches (USGS 2014b). 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 near shore waters (Waythomas and Waitt 1998; Waitt and Begét 2009).

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 that damaged AVO infrastructure and equipment on the north shore of the island (Neal et al. 2009). Pyroclastic flows and debris avalanches moving rapidly down the volcano flank can extend beyond tidelands, potentially generating tsunamis (Waythomas and Waitt 1998; Neal et al. 2009). 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).

5. Lahars and Floods

Various types of flow 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 (mudflows) and floods. Lahars may contain large boulders, sand, or silt, and travel quite quickly, or they may subside into smaller flooding events. 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).

6. Lava Flows

Lava flows at Augustine Volcano generally move slowly down slope and, as was the case in 2006, can produce steep fronts that shed debris, forming fast-moving block- and ash flows (Neal et al. 2009).

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. 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 would likely only pose a threat to those in the vicinity of the cone (Waythomas and Waitt 1998).

8. Tsunamis

Tsunamis can be generated by large displacements of the seafloor during subduction zone earthquakes. The majority of the damage to local communities from the March 27, 1964 earthquake resulted from the associated tsunamis that followed the land displacement and seismic shaking. The powerful and sustained ground shaking during the 1964 earthquake triggered many under water slides along the coast, which resulted in tsunami activity. The waves were responsible for 31 of the 114 casualties in the various communities. The seismic sea waves that struck the coast of the Gulf of Alaska damaged property as far south as northern California. Extensive damage was observed to the coast including scoured shorelines, smashed trees, displaced driftwood, and shoreline deposits. Violent local waves generated by under water slides caused major damage to adjacent shorelines and casualties in the city of Seward, Valdez, and Whittier (Plafker 1969b). Tsunamis from the 1964 earthquake are responsible for 16 casualties in Oregon and California (AEIC 2014).

A tsunami can also be generated if large amounts of volcanic debris rapidly enter the surrounding waters during a large eruption of Augustine Volcano. Several historical eruptions have resulted in small-volume pyroclastic flows that reached the surrounding waters. However, only the 1883 eruption appears to have generated a debris avalanche that initiated a tsunami, as observed in 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, although no fatalities were reported (Begét and Kowalik 2006). There is potential for a larger avalanche of debris to flow into lower Cook Inlet and create a larger-scale, radiating tsunami (Power et al. 2010).

The size of a volcanic tsunami is based on several factors: the volume and velocity of debris entering the sea, water depth in the run out zone, and the position of tides during the eruption. 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. However it is difficult to assess the tsunami hazard at Augustine Island because of the lack of geologic evidence and eyewitness accounts (Waythomas and Waitt 1998).

9. Mitigation Measures

Although issuing an exploration license is not expected to have any effects on the license area other than to generate revenue for the state, several geologic hazards exist in the license area that could pose risks to subsequent exploration activities. As discussed above, these potential hazards include earthquakes, volcanoes, and tsunamis. The risks from earthquake damage can be minimized by siting facilities away from potentially active faults and unstable areas, and by designing them to meet or exceed national standards and International Building Code seismic specifications particular to Alaska. Preparedness and response to volcano activities can prevent injuries and loss.

National industry standards sometimes referred to as "technical standards," establish standard practices, methods, or procedures that have been evaluated, tested, and proven by analysis and application. These standards are intended to ensure the safe design, construction, operation, maintenance, and repair of infrastructure.

Because geologic hazards could affect and damage oil and gas infrastructure, State, federal, and local regulations, design and construction standards, and measures in this finding should mitigate those hazards. A complete list of mitigation measures is found in Chapter Nine.

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