January 31, 2018

NORTH SLOPE AREAWIDE OIL AND GAS LEASE SALES

PRELIMINARY Finding of the Director

Alaska Department of
NATURAL RESOURCES
DIVISION OF OIL & GAS

Recommended citation:

ADNR (Alaska Department of Natural Resources). 2018. North Slope areawide oil and gas lease sales. Written finding of the director. January 31, 2018.

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Prepared by:

Alaska Department of Natural Resources

Division of Oil and Gas

January 31, 2018

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Chapter One: Director's Preliminary Written Finding and Decision

The State of Alaska offers oil and gas leases through a program known as "areawide lease sales" conducted by the Alaska Department of Natural Resources (DNR), Division of Oil & Gas (DO&G). The purpose of areawide leasing is to provide regularly scheduled competitive oil and gas lease sales for available state lands within five specific sale areas that have known hydrocarbon potential: the Alaska Peninsula, Beaufort Sea, Cook Inlet, North Slope, and North Slope Foothills. By conducting lease sales on a regularly scheduled basis, the state has a stable, predictable leasing program, which allows companies to plan and develop their strategies and budgets years in advance. Additionally, the public is afforded a consistent process and timeline during which to comment and provide new information on the proposed areawide lease sales.

Every 10 years, the director conducts a region-wide analysis, taking a hard look at the topics required under AS 38.05.035(g), including social, economic, environmental, geological, and geophysical information on the proposed lease sale area, and develops a written finding as part of the best interest finding process. In addition to the 10-year review of an area's best interest finding, DO&G annually issues a call for new information before each subsequent lease sale. The call for new information is a request for any substantial new information that has become available since the issuance of the most recent final best interest finding. The result is increased public input, earlier exploration and development, government efficiency, and mitigation measures that reflect current information.

The DO&G is proposing to offer all available state-owned acreage in the North Slope Areawide oil and gas lease sales to be held from 2018 to 2027. The gross acreage of the lease sale area (Sale Area) is approximately 5.1 million acres.

A. Director's Preliminary Written Finding

In making this preliminary finding, the director weighed the facts and issues known at the time of administrative review, considered applicable laws and regulations, and balanced the potential positive and negative effects of the proposed mitigation measures and other regulatory guidelines. The director preliminarily finds that the potential benefits of the lease sales outweigh the possible negative effects, and that the North Slope Areawide oil and gas lease sales will best serve the interests of the State of Alaska. The discussion of these matters is set out in the accompanying chapters of this preliminary written finding. Based on consideration and discussion of the information contained herein, the director preliminarily finds:

- The Alaska constitution directs the state "to encourage…the development of its resources by making them available for maximum use consistent with the public interest" (Alaska Constitution, art. VIII § 1).
- 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)).

- AS 38.05.035(e)(1)(A) allows the director to establish the scope of the administrative review on which the director's determination is based, and the scope of the written finding supporting that determination.
- AS 38.05.035(e)(1)(B) allows the director to limit the scope of an administrative review and finding for a proposed disposal to a review of applicable statutes and regulations, and facts pertaining to the land, resources, property, or interest in them that the director finds are material to the determination and are known or available to the director during the administrative review.
- AS 38.05.035(e)(1)(C) allows the director to limit a written finding to the disposal phase.
- AS 38.05.035(h) provides that in preparing a written finding under AS 38.05.035(e)(1), the director may not be required to speculate about possible future effects subject to future permitting that cannot reasonably be determined until the project or proposed use for which a written finding is required is more specifically defined.
- At the disposal phase, it is unknown whether tracts offered during the lease sale will receive bids or if leases will be issued for the tracts receiving bids; whether exploration, development, production, or transportation will be proposed on any leased tract; and if subsequent exploration, development, production, or transportation is proposed, what the specific location, type, size, extent, and duration would be.
- All oil and gas activities conducted under oil and gas leases are subject to numerous federal, state, and local laws and regulations with which lessees must comply.
- Potential effects of post-disposal oil and gas activities can be both positive and negative.
- North Slope fish and wildlife species that could be affected by oil and gas activities include, but are not limited to, loons, shorebirds, eiders, raptors, whitefishes, char, Arctic grayling, caribou, bowhead whales, polar bears, and ringed seals. Birds may experience displacement, increased predation, loss of habitat and disturbance. The range and traditional migration routes of caribou may be impacted by oil and gas activity. Polar bears and seals are sensitive to habitat changes and oil pollution. Measures developed to mitigate potential impacts on fish and wildlife are discussed in Chapter Nine.
- Several important subsistence, sport, and personal uses of fish and wildlife could be affected. Subsistence activities are important to Alaska Native communities of the North Slope. For residents of North Slope villages, for example, individual and community identity is tied closely to the procurement and distribution of caribou or bowhead whales. Many people maintain strong cultural and spiritual ties subsistence resources, so disruption of subsistence activities may affect more than just food supplies. Mitigation measures addressing harvest interference avoidance, public access, road construction, and oil spill prevention can mitigate potentially negative impacts.
- Discharges of oil, gas, and hazardous substances into North Slope land, water, and air may harm habitats and fish and wildlife populations or resident health. Improved design, construction, operating techniques, proper handling, storage, spill prevention measures, and disposal of such substances can mitigate impacts.

- Communities located in the North Slope Borough could benefit through economic opportunity such as the collection of property taxes, state and local government spending of oil and gas revenues, and increased employment in areas of development. lower fuel prices if oil or gas is produced.
- Most potentially negative effects of oil and gas activities on fish and wildlife species, habitats, and their uses, and local communities, can be mitigated through additional stipulations imposed on the subsequent oil and gas activities if they are not adequately addressed by federal, state, or local law.

The locations and characteristics of the specific tracts that may receive bids in future lease sales may allow DNR to determine requirements and impacts directly associated with proposed operations on those tracts. DNR will also determine additional requirements necessary to protect the state's interest in approval of later phase activities.

B. Preliminary Decision: Request for Public Comment

The director of DO&G has made a preliminary finding that disposal of oil and gas resources in the Sale Area is in the best interest of the state. The state is sufficiently empowered through constitutional, statutory, and regulatory regimes, terms of the lease sale, lease, contract, and plans of operations to ensure lessees conduct their activities safely and in a manner, that protects the environment and maintains opportunities for existing and anticipated uses.

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

Comments must be in writing and received by April 2, 2018, in order to be considered and must be sent to Best Interest Findings:

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

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

Following review of comments on this preliminary best interest finding and any additional available information, the director will make a final determination whether disposal of oil and gas resources in the Sale Area is in the best interest of the state, and will issue a final finding and decision. The final finding and decision will be issued at least 90 days before the 2018 North Slope Areawide lease sale. To be eligible to file a request for reconsideration under AS 38.05.035(i), a person must provide written comments during the comment period set out in the previous paragraph. Additional information regarding the public comment process and requests for reconsideration and appeals can be found in Chapter Two of this document. A copy of the final decision can be sent to any person commenting on the preliminary decision, and will include an explanation of the appeal process.

Director, Division of Oil and Gas — Date: 01/31/2018

Chapter Two: Introduction

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Chapter Two: Introduction

The State of Alaska is proposing to offer all available state-owned acreage in the North Slope Areawide oil and gas lease sales to be held from 2018 to 2027. The proposed lease disposal area contains approximately 5,100,000 acres which generally consists of all state-owned lands lying between the National Petroleum Reserve-Alaska (NPR-A) on the west and the mean high water mark of the extreme west bank of the Canning River on the east, and from the Beaufort Sea in the north to the Umiat Meridian Baseline in the south. Some acreage not owned or selected by the state may be included within identified sale tracts, but only free and unencumbered state-owned oil and gas mineral estates will be included in any leases issued. The boundaries of the North Slope Areawide sale area (Sale Area) are discussed further in Chapter Three.

This is the director's preliminary written finding and decision issued under AS 38.05.035(e). It discusses whether the interests of the state will best be served through the disposal of interests in state oil and gas through lease sales in the Sale Area. After publication of this preliminary finding and public comments are addressed, the director will issue a final finding and decision regarding the Sale Area.

A. Constitutional Authority

The Alaska Constitution provides that the general policy of the state 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). The legislature has been empowered to make all policy decisions to carry out these general goals, as well as to provide the policies and procedure for the lease, sale, and granting of state-owned land (Alaska Constitution Article VIII, §§ 8, 9, and 12). The Alaska Land Act guides the land management and disposal policy of the state. The Act, codified at AS 38.05, provides the commissioner of the Department of Natural Resources (DNR) the authority to select, manage, and dispose of state lands, and directs DNR to implement the requisite statutes.

The legislature has found that the people of Alaska have an interest in the development of Alaska's oil and gas resources to maximize the economic and physical recovery of the resources; maximize competition among parties seeking to explore and develop the resources; and maximize use of Alaska's human resources in the development of the resources. It is in the state's best interest to encourage an assessment of its oil and gas resources and to allow the maximum flexibility in the methods of issuing leases to recognize the many varied geographical regions of the state and the different costs of exploring for oil and gas in these regions, and to minimize the adverse impact of exploration, development, production, and transportation activity. Further, it is in the best interests of the state to offer acreage for oil and gas leases or for gas only leases, specifically including state acreage that has been the subject of a best interest finding at annual areawide lease sales (AS 38.05.180(a)(1)–(2)). DO&G has identified five areas of moderate to high potential for oil and gas development and designated these areas, including the North Slope Areawide, for leasing through competitive oil and gas sales.

B. Written Findings

Alaska statutes govern the disposal of state-owned mineral interests. Under AS 38.05.035(e), the director may, with the consent of the commissioner, dispose of state land, resources, property, or interests after determining in a written finding that such action will serve the best interests of the state. The written finding is known as a "best interest finding" and describes the proposed Sale Area, considers and discusses the potential effects of the lease sales, describes measures to mitigate those effects, and constitutes the director's determination whether the interests of the state will be best served by the disposal. The Division of Oil and Gas (DO&G) issues both a preliminary written finding and a final written finding, providing opportunity for public comment after the preliminary finding is released. The final written finding will include a discussion of material issues raised during the public comment period, as well as a summary of the comments received.

1. Applicable Law and Facts

The best interest finding requirements outlined in AS 38.05.035 provide the Department of Natural Resources (DNR) with procedures to ensure Alaska's resources are developed for the maximum benefit of the state as mandated by article VIII, § 2 of the Alaska Constitution. The authorities applicable to this written finding include the requirements and procedures set out in AS 38.05.035(e)–(m), and the case law applicable to the disposal phase.

Under AS 38.05.035(e), the director may not dispose of state land, resources, or property, or interests therein, unless the director first determines in a written finding that such action will serve the best interests of the state. The provisions in AS 38.05.035(e) set out the scope of review and process for the written finding.

The statute also expressly empowers DNR to review projects in phases, allowing the analysis of proposed leasing to focus on the issues pertaining to the disposal phase and the reasonably foreseeable significant effects of leasing. (AS 38.05.035(e)(1)(C)). Further explanation of the statutory direction is provided in the sections below. The regulatory authorities governing exploration, development, production, and transportation of oil and gas development are discussed further in Chapter Seven.

2. Scope of Review

As required by AS 38.05.035(e)(1)(A)–(C), the director, in the written finding:

- shall establish the scope of the administrative review on which the director's determination is based, the scope of the written finding supporting that determination, and the scope of the administrative review and finding may only address reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal;
- may limit the scope of an administrative review and finding for a proposed disposal to a review of applicable statutes and regulations, facts and issues material to the determination and known to the director or knowledge of which is made available to the director during the administrative review, and issues that, based on the applicable statutes, regulations, facts, and the nature of the uses sought to be authorized by the disposal the director finds

are material to the determination of whether the proposed disposal will serve the best interests of the state; and

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

a. Reasonably Foreseeable Effects

The scope of this administrative review and preliminary finding addresses only the reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal (AS 38.05.035(e)(1)(A)).

A detailed discussion of the possible effects of unknown future exploration, development, and production activities is not within the scope of this best interest finding. Therefore, the director has limited the scope of this preliminary finding to the applicable statutes and regulations, facts, and issues pertaining solely to the North Slope Areawide lease sale area, and the reasonably foreseeable significant effects of the North Slope Areawide lease sale disposals. However, this finding does discuss the potential cumulative effects, in general terms, that may occur with oil and gas activities related to lease sales, exploration, development, production, and transportation within the Sale Area and any mitigation measures in the lease terms as required by AS 38.05.035(g)(1) and (2).

b. Matters Considered and Discussed

In a preliminary or final written finding, the director must consider and discuss facts related to topics set out under AS 38.05.035(g)(1)(B)(i)–(xi) that are known at the time the finding is being prepared. The director must also consider public comments during the public comment period and within the scope of review set out in Sections A and B.1–2 of this Chapter.

To aid those interested in reviewing and commenting on this preliminary best interest finding, this document is organized for ease of reading and reviewing, and does not necessarily follow the order as found in AS 38.05.035(g)(1)(B) (Table 2.1).

Table 2.1.—Topics required by AS 38.05.035(g)(1)(B).

AS 38.05.035(g)(1)(B) subsection number	Description	Location in this document
i	Property descriptions and locations	Chapter Three
ii	Petroleum potential of the Sale Area, in general terms	Chapter Six
iii	Fish and wildlife species and their habitats in the area	Chapter Four
iv	Current and projected uses in the area; including uses and value of fish and wildlife	Chapter Five
v	Governmental powers to regulate the exploration, development, production, and the transportation of oil and gas or of gas only	Chapter Seven
vi	Reasonably foreseeable cumulative effects of exploration, development, production, and transportation for oil and gas or for gas only on the Sale Area, including effects on subsistence uses; fish and wildlife habitat and populations and their uses, and historic and cultural resources	Chapter Eight

AS 38.05.035(g)(1)(B) subsection number	Description	Location in this document
vii	Lease stipulations and mitigation measures, including any measures to prevent and mitigate releases of oil and hazardous substances, to be included in the leases, and a discussion of the protections offered by these measures	Chapter Nine
viii	Method or methods most likely to be used to transport oil or gas from the lease Sale Area, and the advantages, disadvantages, and relative risks of each	Chapter Six
ix	Reasonably foreseeable fiscal effects of the lease sale and the subsequent activity on the state and affected municipalities and communities, including the explicit and implicit subsidies associated with the lease sale, if any	Chapter Eight
x	Reasonably foreseeable effects of exploration, development, production, and transportation involving oil and gas or gas only on municipalities and communities within or adjacent to the Sale Area	Chapter Eight
xi	Bidding method or methods adopted by the commissioner under AS 38.05.180	Chapter Two

c. Review by Phase

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

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

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

(ii) the disposal is a disposal of oil and gas, or of gas only, and, before the next phase of the project may proceed, public notice and the opportunity to comment are provided under regulations adopted by the department;

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

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

Here, the director has met condition (i) because the only uses authorized are part of the disposal phase. The disposal phase is the lease sale phase of a project. As defined in *Kachemak Bay Conservation Society v. State, Department of Natural Resources* disposal is a catch-all term for all alienations of state land and interests in state land1. In *Northern Alaska Environmental Center v. State, Department of Natural Resources,* the court further held that a disposal was a conveyance of a property right.2 For an oil and gas development project, the lease is the only conveyance of property rights DNR approves. The lease gives the lessee, subject to the provisions of the lease and applicable law, the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances, as well as the nonexclusive right to conduct within the leased area

[1] 6 P.3d 270, 278 n.21 (Alaska 2000).

[2] 2P.3d 629, 635-36 (Alaska 2000).

geological and geophysical exploration for oil, gas, and associated substances, the nonexclusive right to install pipelines and build structures on the lease area to find, produce, save, store, treat, process, transport, take care of, and market all oil and gas, and associated substances and to house and board employees in its operations on the lease area. While the lessee has these property rights upon entering into the lease, the lease itself does not authorize any oil and gas activities on the leased tracts without further permits from DNR and other agencies. There are no additional property rights to be conveyed at later phases.

Condition (ii) is met because the disposal is for the sale or lease of available land or an interest in land, for oil and gas, or for gas only, scheduled in the oil and gas leasing program under AS 38.05.180(b). Post-disposal phases may not proceed until public notice and the opportunity to comment on the disposal phase is provided under regulations adopted by DNR. Public notice and the opportunity to comment on the disposal phase of a new 10-year areawide best interest finding is provided under AS 38.05.035(e)(5), AS 38.05.945, and 11 AAC 82.415. Moreover, AS 38.05.035(e)(6)(F) requires public notice and the opportunity to comment on the disposal phase for proposed lease sales under AS 38.05.180(d) or AS 38.05.10(w) of acreage subject to a best interest finding issued within the 10 previous years before post-disposal phases may proceed.

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

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

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

3. Process

The process of developing a best interest finding includes opportunities for input from a broad range of participants, including: the public; state, federal, and local government agencies; Alaska Native organizations; resource user groups; non-government organizations (NGOs); and any other interested parties.

a. Request for Agency Information and Preliminary Finding

The process for receiving public input begins with a request for information from state resource agencies, local governments, and Alaska Native corporations. DO&G requests information and data about the region’s property ownership status, peoples, economy, current uses, subsistence, historic and cultural resources, fish and wildlife, and other natural resource values. Using this information and other relevant information that becomes available, DO&G develops a preliminary best interest finding and releases it for public comment (AS 38.05.035(e)(7)(A)).

On April 30, 2014, DO&G issued a Request for Agency Information to initiate the process of gathering information to determine if it is in the state’s best interest to conduct the proposed lease sale disposals within the North Slope Areawide from 2018 to 2027. The Request for Agency

Information was sent to 63 agencies including state and federal agencies and NGOs, 11 boroughs and municipalities, and 27 Native corporations and Village Councils. Most agencies received paper notices via the US Postal Service and 18 received electronic notices via email. The comment period ran from April 30, 2014 to July 30, 2014. Agencies were encouraged to submit comments and information within that 90-day commenting period. DO&G did not receive any comments in response to the Request for Agency Information.

b. Request for Public Comments

Once a preliminary best interest finding is issued, DO&G follows AS 38.05.945(a)(3)(A)–(b)(2) to obtain public comments on the preliminary best interest finding. This statute includes specific provisions for public notice for written findings for oil and gas lease sales under AS 38.05.035(e).

Public comments assist in developing information for the final best interest finding. Information provided by agencies and the public assists the director in determining which facts and issues are material to the decision of whether the proposed lease sales are in the state's best interest, and in determining the reasonably foreseeable, significant effects of the proposed lease sale. Summaries of these comments and the director's responses are published in the final best interest finding (AS 38.05.035(e)(7)(B)). Public comments on this preliminary best interest finding must be received in writing by April 2, 2018.

c. Final Finding

After receiving public comments on the preliminary best interest finding, DO&G reviews all comments and incorporates additional relevant information and issues into the final best interest finding. DO&G will also include a summary of comments received during the public comment period. After considering the information, laws, comments, and issues material to the determination and made available to her during the administrative review, the director with the consent of the commissioner, makes a determination and develops a final written finding which is co-signed by the commissioner. The final best interest finding will be issued at least 90 days before the 2018 North Slope Areawide lease sale (AS 38.05.035(e)(5)(B)).

d. Requests for Reconsideration

A person affected by the final best interest finding who provided timely written comment on this decision may request reconsideration, in accordance with 11 AAC 02. Any reconsideration request must be received within 20 calendar days after the date of issuance of this decision, as defined in 11 AAC 02.040(c) and (d) and may be mailed or delivered to the Commissioner, Department of Natural Resources, 550 W. 7th Avenue, Suite 1400, Anchorage, Alaska 99501; faxed to 1-907-269-8918, or sent by electronic mail to dnr.appeals@alaska.gov. If reconsideration is not requested by that date or if the commissioner does not order reconsideration on his own motion, the final best interest finding will go into effect as a final order and decision on the 31st calendar day after issuance.

Failure of the commissioner to act on a request for reconsideration within 31 calendar days after issuance of the final best interest finding is a denial of reconsideration and is a final administrative order and decision for purposes of an appeal to Superior Court. That decision may then be appealed to Superior Court within 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 the final best interest finding in accordance with 11 AAC 02 before appealing that decision to Superior Court. A copy of 11 AAC 02 may be obtained from any regional information office of the Department of Natural Resources.

The DO&G complies with Title II of the Americans with Disabilities Act of 1990. The final written finding will be made available in alternate communication formats upon request. Please contact the Best Interest Findings Program at 1-907-269-8800 or dog.bif@alaska.gov. Requests for assistance must be received at least 96 hours before the deadline to file a request for reconsideration with the commissioner in order to ensure necessary accommodations can be provided.

C. Annual Lease Sales

Under AS 38.05.035(e)(6)(F) and AS 38.05.180, once a final best interest finding has been issued for an areawide lease sale, DO&G holds annual competitive areawide lease sales under AS 38.05.035(e) and AS 38.05.180. Under these statutes, land that is subject to a best interest finding issued within the previous 10 years may be offered for oil and gas leasing each year for up to 10 years without repeating this comprehensive best interest finding review process. However, before holding a sale, DO&G will determine whether a supplement to the finding is required through the Call for New Information process.

1. Calls for New Information

Approximately nine months before a lease sale, DO&G issues a Call for New Information requesting substantial new information that has become available since the most recent final finding for that Sale Area. This request is publicly noticed, and provides opportunity for public participation for a period of not less than 30 days. After evaluating the information received, the director will determine if it is necessary to supplement the final finding and will either issue a supplement to the finding or a Decision of No New Substantial Information no less than 90 days before the sale. The supplement has the status of a final written best interest finding and is subject to an administrative appeal or a request for reconsideration.

Mitigation measures developed in this North Slope Areawide best interest finding will be attached to leases sold during the term of the finding unless, as a result of new information, the director deems it necessary to change some of the measures, or create additional ones.

2. Bidding Method and Lease Terms

AS 38.05.180(f) and 11 AAC 83.100(a) require competitive bidding for oil and gas leases. For each lease sale under the final North Slope Areawide best interest finding, the commissioner will adopt the bidding method(s) and terms under AS 38.05.180 that the commissioner determines are in the state's best interest. In selecting the bidding method for each North Slope Areawide oil and gas lease sale, DO&G considers and balances the following state interests: protecting the state's ownership interest in hydrocarbon resources; promoting competition among those seeking to explore and develop the area; encouraging orderly and efficient exploration and development; and, the need to generate revenue for the state.

The bidding method(s) and terms may not be the same for each lease sale over the 10-year term of this best interest finding. The bidding method(s) adopted for a lease sale will be published in the pre-sale notice describing the interests to be offered, the location and time of the sale, and the terms and conditions of the sale (AS 38.05.035(e)(6)(F)).

Leasing of oil and gas resources under AS 38.05.180(f) and 11 AAC 83.100 must be by competitive bidding, but bidding methods may vary from sale to sale. Following a pre-sale analysis, the commissioner may choose from the bidding methods listed in AS 38.05.180(f)(3):

- a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5% in amount or value of the production removed or sold from the lease;
- a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5% in amount or value of the production removed or sold from the lease and a fixed share of the net profit derived from the lease of not less than 30 percent reserved to the state;
- a fixed cash bonus with a royalty share reserved to the state as the bid variable but no less than 12.5% in amount or value of the production removed or sold from the lease;
- a fixed cash bonus with the share of the net profit derived from the lease reserved to the state as the bid variable;
- a fixed cash bonus with a fixed royalty share reserved to the state of not less than 12.5% in amount or value of the production removed or sold from the lease with the share of the net profit derived from the lease reserved to the state as the bid variable;
- a cash bonus bid with a fixed royalty share reserved to the state based on a sliding scale according to the volume of production or other factor but in no event less than 12.5% in amount or value of the production removed or sold from the lease;
- a fixed cash bonus with a royalty share reserved to the state based on a sliding scale according to the volume of production or other factor as the bid variable but not less than 12.5% in amount or value of the production removed or sold from the lease.

Not later than 45 days before the lease sale, DO&G issues a public notice describing the tracts to be offered, the location and time of the sale, and the terms and conditions of the sale (AS 38.05.035(e)(6)(F)(ii). The announcement may include information such as a tract map showing generalized land status, estimated tract acreages, and instructions for submitting bids. The lease sale process consists of opening and reading the sealed bids and awarding a lease to the highest bid per acre by a qualified bidder on a tract. DO&G verifies the state's ownership interest only for the acreage within the tracts that receive bids. Only those state-owned lands within the tracts that are determined to be free and clear of title conflicts are available to lease. DO&G reserves the right to defer potential lease sale tracts at any point up to lease award.

3. Lease Adjudication and Lease Award

The North Slope Areawide is divided into lease sale tracts. The extent of the state's ownership interest within tracts is generally not determined before a lease sale. Instead, following each lease sale, and before awarding leases, DO&G will verify land available for leasing and acreage within tracts receiving bids. Determination of a lease award may take several months following a lease sale depending on the number of tracts receiving bids and the complexity of lease history and ownership within the tract. It is possible that a lease cannot be awarded on a tract included in a lease sale. Lands within a tract will not be leased if they are not state-owned, subject to an existing oil and gas lease, clouded by title claims, within tracts deferred or deleted from sale, subject to pending applications or administrative appeals or litigation, or otherwise determined by DO&G to be unavailable for leasing. DO&G may determine that no lands within a tract are available for leasing and issue a notice of no award. Further, DO&G reserves the right to defer or delete acreage or tracts from the sale at any time up to lease award. Should a potential bidder require land title, land status, or survey status information for a tract before submitting a bid, it will be the bidder’s responsibility to obtain that information from DNR and federal public land records.

Chapter Three: Description of the North Slope Lease Sale Area

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Chapter Three: Description of the North Slope Lease Sale Area

AS 38.05.035(g)(1)(B)(i) requires that the director consider and discuss the property descriptions and locations of the North Slope Areawide (Sale Area). The following overview includes information material to the determination of whether the lease sales will best serve the state's interest (AS 38.05.035(e)(1)(B)(iii)). It is not intended to be all inclusive.

A. Location and General Description

The Sale Area consists of over 5.1 million acres of state owned land and waters located between the eastern boundary of the National Petroleum Reserve-Alaska (NPR-A) as described in Executive Order 3797-A on the west, the western boundary of the Arctic National Wildlife Refuge (ANWR) described in Public Land Order (PLO) 2214 as the mean high water mark of the extreme west bank of the Canning River to the east, and from the Beaufort Sea coastline in the north to the Umiat Meridian Baseline in the south. The Sale Area includes all lands jointly owned by the State of Alaska and the Arctic Slope Regional Corporation (ASRC) and the Nuiqsut Subsurface described in the 1991 Settlement Agreement between ASRC and the State of Alaska. This includes those portions of the tracts jointly owned by the State of Alaska and ASRC that were previously included within the boundary as described in the 2009 Beaufort Sea Areawide Final Best Interest Finding and shown in Figure 3.2. Tracts jointly owned by the State of Alaska and ASRC may be subject to terms or conditions not applicable to wholly-owned state tracts. Additionally, lessees are cautioned that the state has unresolved land selections within the Sale Area, and the eastern boundary of the Sale Area is based on the State of Alaska's interpretation of PLO 2214. The Sale Area is contained entirely within the North Slope Borough (NSB).

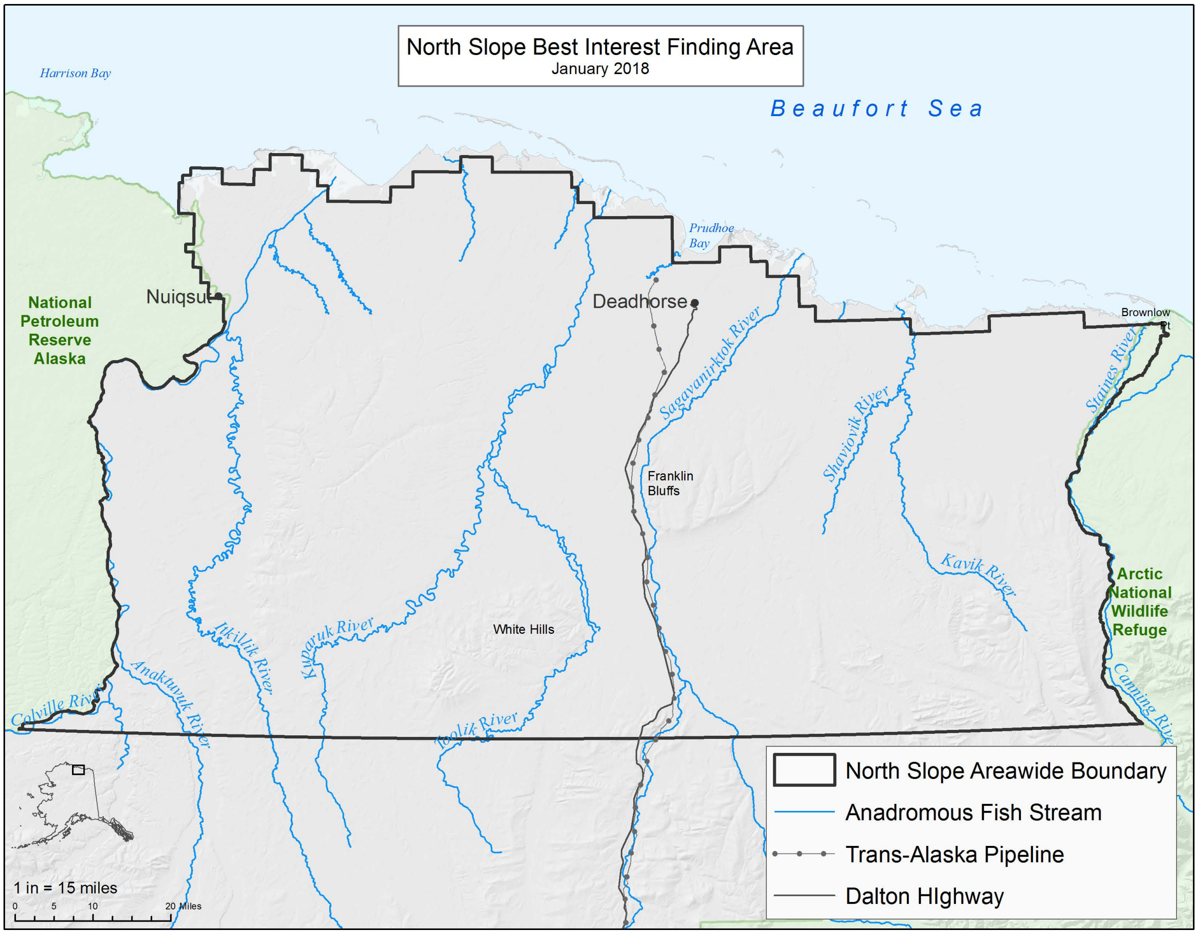

Figure 3.1.—Sale Area.

Prominent geographic features include the White Hills and Franklin Bluffs. Following the Sagavanirktok River to the south, the first 60 miles of the Trans-Alaska Pipeline System bisects the Sale Area. The Sale Area also includes portions of numerous rivers, including the Colville, Miluveach, Kachemach, Itkillik, Anaktuvuk, Chandler, Ugnuravik, Sakonowyak, Kuparuk, Toolik, Putuligayuk, Sagavanirktok, Kadleroshilik, Ivishak, Shaviovik, Kavik, Staines, and Canning.

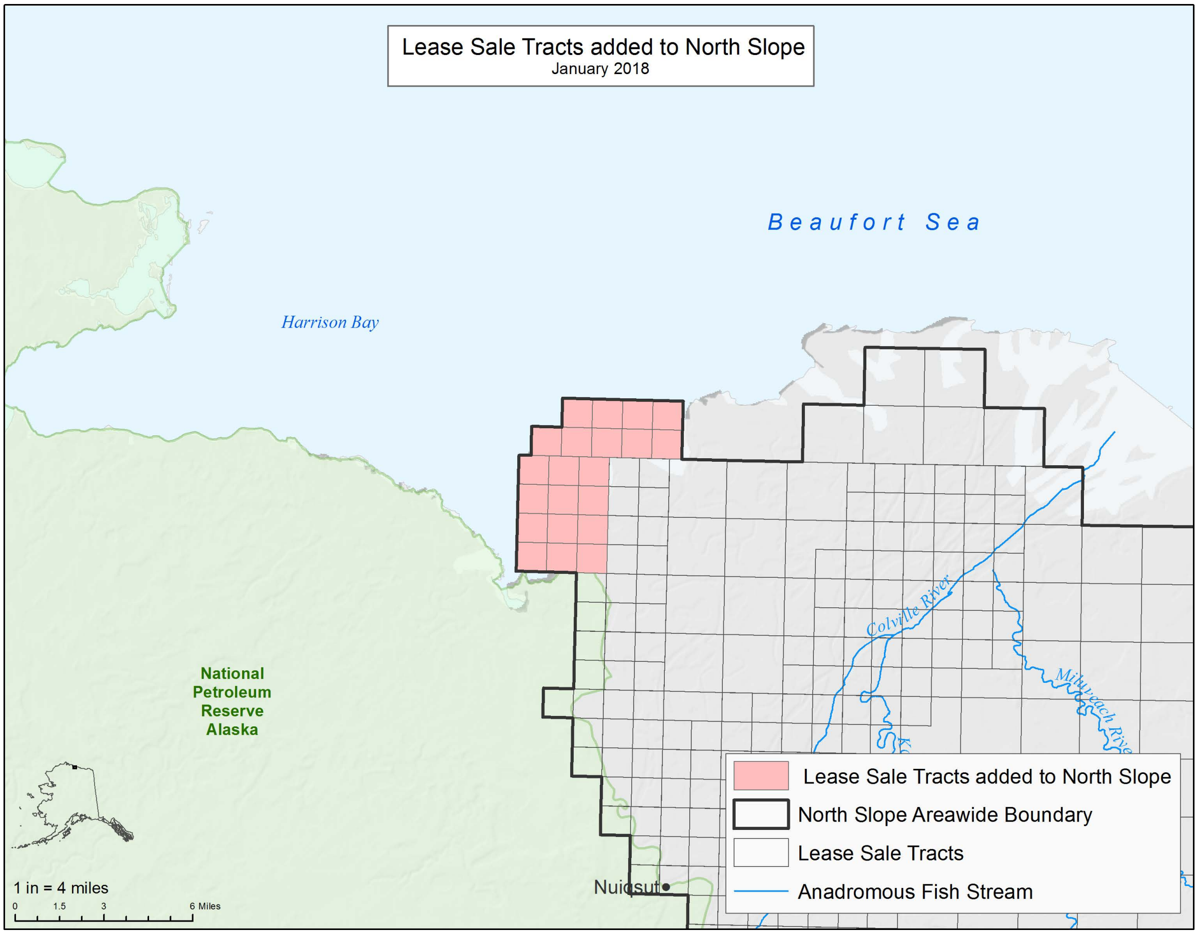

Figure 3.2.— New areawide boundary surrounding jointly owned tracts

B. Land and Mineral Ownership

The Alaska Statehood Act granted to the State of Alaska the right to select over 102.5 million acres of land from the federal public domain to serve as an economic base for the new state. The Act also granted Alaska the right to all minerals underlying these selections and specifically required the state to retain this mineral interest when conveying its interests in the land (Public Law 85-508, 72 Stat. 339). Therefore, when state land is conveyed to an individual citizen, local government, or other entity, state law requires that each contract for the sale, lease, or grant, of state land, and each deed, to state land, properties, or interest in state land made under AS 38.05 or AS 38.08 reserve the mineral rights for the state (AS 38.05.125). Furthermore, state law reserves to the state, its lessees, and successors, the right to reasonable access to the surface for purposes of exploring for, developing and producing the reserved mineral. Surface owners are entitled to damages under AS 38.05.130, but may not deny reasonable access.

The Alaska Native Claims Settlement Act (ANCSA), was enacted by Congress in 1971 to resolve aboriginal title and foster economic development for Alaska Natives (85 Stat 688, *codified as amended at* 43 U.S. Code § 1601-1629h). ANCSA established 13 for-profit regional corporations, 12 of which represented the geographic regions of the state with each region composed of Alaska

Natives having a common heritage and sharing common interests. The 13th regional corporation was created to represent those Alaska Natives residing outside of Alaska. ANCSA also created 225 for-profit village corporations which are dispersed within the 12 geographic regions. ANCSA granted the new regional Native corporations the right to select and obtain from the federal domain, the land and mineral estates within the regional Native corporation boundaries. It also allowed Native village corporations and individual Alaska Natives to receive surface estate interests in land. However, overlapping selections created conflicts and delays in conveying the land from the federal government, and some selected lands have yet to be conveyed.

1. Surface Estate

The surface estate of the uplands in the Sale Area fall into one of three ownership categories: land owned by the State of Alaska, land owned by ARSC or by the Kuukpik Village Corporation of Nuiqsut, or land owned by Native allottees. Except for the bed of the Colville River, which is owned by the state, the surface estate of the uplands within the Colville River delta portion of the Sale Area is owned by the Kuukpik Village Corporation or Native allottees. Kuukpik Village Corporation land includes lands within and outside of NPR-A.

a. Village owned lands outside of NPR-A

ANCSA allowed the Kuukpik Village Corporation of Nuiqsut (Kuukpik) to select and acquire lands in the Colville River delta. Kuukpik Village Corporation owns approximately 146,000 acres of surface lands in and around the community of Nuiqsut. ANCSA allowed the ASRC to acquire the subsurface estate beneath these lands. The 1974 agreement between ASRC, Kuukpik, and the State of Alaska, and the 1992 settlement agreement between ASRC and Kuukpik, gave the right of access to Kuukpik's surface lands. ASRC and the State of Alaska, their successors, assignees, and lessees, may conduct oil and gas activities on Kuukpik's lands east of NPR-A under the provisions of the 1992 settlement agreement, the lease, and, to the extent applicable, the requirements of AS 38.05.130.

b. Native allotments

In 1906, Congress passed the Alaska Native Allotment Act, which authorized the Secretary of the Interior to allot individual Alaska Natives a homestead of up to 160 acres of land. Subject to valid existing rights, allottees could take title to the surface estate of certain lands while the United States and Regional Corporations retained their interest in the subsurface estate. Title conveyed under this Act is held in restricted status, and the surface estate cannot be alienated or encumbered without approval from the Bureau of Indian Affairs (BIA) (43 CFR 2561.3). However, some allottees have successfully applied to the BIA to have the restrictions removed and were issued a patent in fee which vested all management authority in the allottee. The surface estates of certain lands within the Sale Area are owned by Alaska Native allottees. Should jointly-owned lands be offered and leased, rights to exploration and development of the oil and gas resources may not be exercised until the lessees make provisions to compensate the landowner for full payment for all damages sustained by the owner, by reason of entering upon the land, as required by the leases and AS 38.05.130 as applicable.

2. Subsurface Estate

a. Agreement between State of Alaska and Arctic Slope Regional Corporation

The subsurface estate within the portion of the Sale Area in the Colville River delta is jointly owned by the state and ASRC. The joint ownership is an agreement between the state and ASRC signed December 17, 1991, approved by the legislature, and effective May 27, 1992. The agreement settled a legal dispute concerning North Slope mineral ownership resulting from a 1974 agreement in which ASRC and the state agreed to exchange lands near Nuiqsut and Point Lay. Under the 1991 settlement, the state and ASRC agree to jointly own undivided interests in the mineral estate of the disputed lands, including the subsurface estate beneath the tide and submerged lands as well as the bed of the Colville River. The 1991 settlement involves the mineral estate and does not change the surface ownership.

The 1991 settlement grants the state the executive right to hold oil and gas lease sales jointly for itself and for ASRC. When such lands are leased, the state separately administers the lease of its undivided interest in the subsurface. The lessee must comply with the permitting and approval requirements from both the state and ASRC. This allows the state and ASRC to have an identical but separate relationship with the lessee.

Under the settlement agreement, the state does not give up any of its duties to the public imposed by state or federal law. The state still must determine whether a sale is in the best interests of the state, and it must follow requirements for leasing, exploration, development, and production. The state retains all rights under state law to ensure that development activity on leased tracts complies with laws governing natural resource management and protection.

b. Agreement Between Arctic Slope Regional Corporation and Kuukpik Corporation

In 1987, ASRC entered into an agreement with the Kuukpik Corporation to exercise its option under section 1431(o) of the Alaska National Interest Lands Conservation Act (ANILCA), to acquire the subsurface estate of lands selected or conveyed to Kuukpik within the NPR-A (Public Law 96-487, 94 Stat 2371, 2542). Under the agreement, ASRC agreed to not engage in any exploration and development activities in the ASRC subsurface without first obtaining Kuukpik’s consent. Subsequently, ASRC received title to the lands subject to this agreement. The State of Alaska received its undivided interest to the subsurface estate beneath these lands from ASRC in 1992, 1993, and 1994. The state’s title and leases issued on these lands are, therefore, also subject to the 1987 ASRC-Kuukpik agreement.

Before state Lease Sale 75 in December 1992, a dispute arose regarding the extent of Kuukpik’s consent rights under ANCSA and cast doubt on the validity of the 1987 agreement. Kuukpik asserted that its consent rights extended to all lands owned by Kuukpik, including the entire ASRC-State of Alaska subsurface. ASRC argued that Kuukpik’s consent rights were limited to the area immediately surrounding the Native village of Nuiqsut. Kuukpik and ASRC entered into agreements dated November 23, 1992 and August 27, 1997, in which Kuukpik granted consent to development of the oil and gas resources on the disputed lands, the other leases jointly held by ASRC and the state over which Kuukpik had surface rights, and the leases in which ASRC had an interest. Under the August 27, 1997 Consent Agreement with ASRC, Kuukpik receives an overriding royalty from ASRC for consenting to oil and gas activities on the Kuukpik NPR-A lands.

C. Historical Background

The North Slope Arctic coast served as a migration corridor for early nomads arriving from Asia across the Bering land bridge. Evidence of human occupation and use of the Arctic coastal plain dates back to 10,000 B.C. (Goebel et al. 2008). The new migrants began exploring the Brooks Range foothills when glaciers began retreating to the Brooks Range. The Paleoindian period between 13,700 and 9,800 years ago, was the first widespread Native American cultural tradition that was well-documented by the archaeological record. These groups were likely small, mobile bands that hunted large game. As the environment changed at the end of the Pleistocene era and the large mammals on which they survived disappeared, the Paleoindian tradition disappeared (Raff et al. 2015). The Mesa site, south of Utqiaġvik in the foothills of the Brooks Range, is the best documented site of the period (Kunz and Reanier 1995).

Marine mammal harvesting on winter sea ice has occurred for at least 4,000 years, and evidence of whaling is 3,400 years old. The record of human existence on the North Slope is characterized by several distinct cultural periods marked by changes in tool style. The environmental characteristics of the Arctic shaped Iñupiat culture into a semi-nomadic society with a tradition of whaling and an emphasis on seasonal inland hunting. This pattern of land use remained unchanged until the second half of the 19th century with the arrival of westerners and new tools and other natural events such as caribou population decline (Kunz et al. 2003; Whitridge 2004).

North Slope Iñupiat traded with Asia across the Bering Strait as early as the mid-1700s. Canadian and Alaska Iñupiat established trading centers at the mouth of the Colville River and Barter Island. European explorers and fur traders began arriving in the Sale Area in the 1820s and 1830s. This contact introduced metal tools, traps, and guns to support trading and hunting. Russian trading posts were established from Norton Sound southward (Darigo et al. 2007; Kunz et al. 2003).

The discovery of bowhead whale paths led to a dramatic increase in commercial whaling activity between 1850 and 1890. Several whaling stations were built along the coast and provided regular contact and trading with the Iñupiat population. Steamships replaced sailing vessels facilitating year-round access. During the final quarter of the nineteenth century, smallpox and influenza outbreaks decimated North Slope Iñupiat populations (Darigo et al. 2007; Bell 2016). A simultaneous decline in caribou populations resulted in famine and caused inland Iñupiat to relocate to coastal communities, such as Utqiaġvik. By 1910, the population decline reduced the Iñupiat population to between 20 and 25 percent of its 1850 population (Darigo et al. 2007).

In 1900, a report by the US Navy provided the first written documentation about petroleum resources in the Sale Area by verifying oil shale deposits along the Etivluk River. The US Geological Survey (USGS) completed the first comprehensive survey for the Sale Area in 1901 and published the results in 1904. The USGS report noted the presence of geological formations that could have petroleum deposits as well as natural oil seepages near Cape Simpson. The federal government began exploring for oil in 1923 with the establishment of the Naval Petroleum Reserve № 4 (Reed 1958).

By World War I, declining whale populations and decreased demand for whale oil and baleen brought an end to the commercial whaling period. However, demand for fur, especially arctic fox, resulted in a continued presence of westerners along the Beaufort Coast and North Slope. Native residents engaged in trapping which provided income for non-subsistence resources. By 1914, trapping camps were established from Utqiaġvik to the Canadian border. In the 1930s, the price of fur dropped significantly, forcing many trappers to leave the region near the lower Colville River (Darigo et al. 2007).

World War II brought an influx of military personnel into Alaska. Petroleum exploration ramped up towards the end of the war, and post-war military construction provided job opportunities. In 1946, the US Navy, through its Office of Naval Research, began development of a research program for Arctic studies. The project moved quickly, and in 1947 the first researchers arrived in Utqiaġvik and used an area adjacent to the Navy's main supply camp for exploration activities in the Naval Petroleum Reserve № 4 to establish the Arctic Research Laboratory (NSB 2015d). Also during that time, the US Air Force (USAF) had arrived on Barter Island to establish the Barter Island Long Range Radar Station, a Distant Early Warning Line network station in Kaktovik. To develop the 5,000-foot-long airstrip and hangar, the USAF seized the land that had long been used as a trading post and marked the beginning of Kaktovik as a permanent settlement, and the village was relocated to an adjacent location on the island. As the military installation grew, the village was relocated two more times, in 1953 and 1964 (NSB 2015b).

The contemporary period of modernization and change for the North Slope began in the 1960s. The discovery of the Prudhoe Bay oilfield in 1967 prompted a renewed interest in petroleum exploration and development (Darigo et al. 2007). However, before oil reserves could be developed, issues regarding title to North Slope lands needed to be resolved. The state began identifying and selecting lands under the Alaska Statehood Act in 1959. State selections quickly gave rise to concerns regarding aboriginal land claims, and Alaska Natives began forming local and regional organizations to protest federal transfers of lands to the state. In 1966, the Secretary of the Interior issued an informal freeze on the transfer of federal lands, and in 1968 the Secretary issued Public Land Order 4582, which withdrew all public lands in Alaska from selection eligibility until the end of 1971. A few weeks before PLO 4582 expired, Congress passed the Alaska Native Claims Settlement Act (ANCSA) which authorized the formation of Alaska Native village and regional corporations and settled Native land claims by cash payment and land grants (ADNR 1987; Boyce and Nilsson 1999).

D. Communities

1. North Slope Borough

The Sale Area lies entirely within the NSB, a non-unified home rule borough incorporated in 1972, whose boundaries extend from the Chukchi Sea to the Canadian border and include the entire North Slope of Alaska. The NSB is the largest borough in Alaska covering about 89,000 square miles of tundra and upland areas, over 15 percent of the state's total land area. The borough includes approximately 5,900 square miles of adjacent state waters, generally the coastal waters out to three nautical miles from shore. The North Slope is home to Alaska's major oil production facilities at Prudhoe Bay (DOLWD 2015c).

The NSB adopted its Home Rule Charter in 1974 that allows it to exercise any legal governmental power in addition to its power of taxation, property assessment, education, and planning and zoning services. The borough government consists of an elected mayor, a eleven-member assembly, a seven-member school board, and an eight-member planning commission (DCCED 2016c).

The NSB is the regional government for the eight villages within its boundary: Anaktuvuk Pass, Atqasuk, Kaktovik, Nuiqsut, Point Hope, Point Lay, Utqiaġvik, and Wainwright. As the regional government for these villages, the borough is responsible for providing public works, utilities, health, and other public services to borough communities. A mayor and an elected city council typically govern the communities. The cities have the power of taxation and may exercise planning, platting, and land use regulation if that authority is delegated by the borough.

All North Slope communities have federally-recognized tribal governments, and each village has an active tribal council. In addition to the local governing bodies, there are two regionally active tribal organizations. The Iñupiat Community of the Arctic Slope (ICAS) is a federally-recognized tribal organization and aids villages in areas of realty, transportation, and resource management programs. The Arctic Slope Native Association (ASNA) has been active in the NSB for many years, but the primary foci of the organization in recent years are healthcare and social services. In addition, Maniilaq Association (Kotzebue) and Tanana Chiefs Conference (Fairbanks) provide health and social services in some borough villages.

In 2015, the estimated population of the NSB was 9,895. There are nine communities in the NSB with populations that range from less than 300 to more than 4,000 (DOLWD 2016). Approximately 54 percent of the population was American Indian and Alaska Native (DOLWD 2015c). Borough per capita income in 2014 was estimated to be $46,457; median household income was $80,761; and, median family income was $82,500. About 10 percent of the borough's population was estimated to be below the poverty level (DCCED 2016c).

Employment data for the borough varies based upon whether the transient work force is considered or if the data is based solely on the permanent work force. An analysis of the total workforce, transient population included, between 2008 and 2013 shows that 61 percent of the borough's workforce was employed in the natural resource and mining industry. However, if the transient workforce is excluded, approximately 68 percent of the NSB work force was employed in local government, education, and the health services industry. Local government accounts for 59 percent of that total (DOLWD 2015c). The NSB is supported almost exclusively by property taxes on oil industry facilities. In 2016, revenues from oil and gas related property taxes totaled over $368 million and accounted for 93 percent of the borough's total tax levy (NSB 2016).

Most North Slope communities are accessible only by air, and air travel is the primary means of year-round long distance transportation. One airline provides passenger service between Utqiaġvik and the state's largest cities, and smaller commuter airlines travel between Utqiaġvik and the villages (DCCED 2016c). Communities in the NSB tend to be very spread apart. Distances between communities varies from 58 miles between Utqiaġvik and Atqasuk to 588 miles between Kaktovik and Point Hope. The 498-mile Dalton Highway is the only road connecting the NSB to Fairbanks and the main Alaska Highway system (BLM 2015).

2. Utqiaġvik

Utqiaġvik, formerly known as Barrow, is the economic, transportation, and administrative center for the NSB. On October 4, 2016, the community changed its name from Barrow to Utqiaġvik (DCCED 2017), becoming official on December 1, 2016. Utqiaġvik is located 10 miles south of Point Barrow on the Chukchi Sea coast. The area encompasses 18.4 square miles of land and 2.9 square miles of water (DCCED 2017). The City of Utqiaġvik was incorporated in 1958 as a first-class city. The city has a seven-member council that is elected by the residents of Utqiaġvik who are eligible to vote. Six council members are elected to specific seats and the Mayor is elected at large (NSB 2015d).

In 2015, the estimated population for Utqiaġvik was 4,554 (DOLWD 2016). Approximately 61 percent of the population is Alaska Native or American Indian. In 2014, the estimated per capita income for Utqiaġvik was $30,324; median household income was $90,500; and, median family income was $95,000. About 12 percent of the Utqiaġvik's population was estimated to be below the poverty level (DCCED 2017). Local government employs 53 percent of the total workforce, 46 percent is employed in the private sector, and state government employs one percent of the workforce (WHPacific 2015).

Year-round access is provided by air travel. The state owns and operates the Wiley Post-Will Rogers Memorial Airport, and it serves as the regional transportation center for the NSB. The airport has controlled airspace and a 7,100-foot-long asphalt runway that can accommodate larger commercial airplanes such as a Boeing 737. Marine and land transportation provide seasonal access (DCCED 2017).

The NSB school district operates four schools in Utqiaġvik in addition to Iḷisaġvik College. The Fred Ipalook Elementary School provides education from pre-kindergarten through fifth grade. The Eben Hopson Middle School provides education for students in grades six through eight. The Utqiaġvik High School provides education for students in grades nine through twelve. The Kiita Community Learning Program is an alternative high school. Iḷisaġvik College is the only federally-recognized tribal college in Alaska. It offers higher education opportunities for Utqiaġvik and North Slope residents. The common goal for all educational programs, especially at high school and college levels, is to prepare students to participate in the job market, tailoring many programs to meet the needs of employers of the North Slope (NSB 2015d).

3. Nuiqsut

The community of Nuiqsut is located approximately 10 miles south of the Beaufort Sea coast on the Niġlik channel of the Colville River (DOLWD 2016; WHPacific 2015). In 1973, 27 families traveled over 130 miles from Utqiaġvik to the Colville River delta to permanently resettle the Kuukpikmuit ancestral homeland. The community was named Nuiqsut, for earlier camps and settlements on the main channel of the river. The return to Nuiqsut in 1973 was motivated by a desire to revive traditional Iñupiat values of hunting and fishing, and experience Iñupiat social and cultural life. In 1974, the ASRC funded construction of the modern village, and the City of Nuiqsut was incorporated in 1975 (NSB 2015c; DCCED 2016d).

Nuiqsut is undergoing social and economic change due to its proximity to oil and gas development. The Alpine oilfield is located eight miles from Nuiqsut and partially located on lands owned by the Kuukpik Native Corporation and the ASRC. In 2015, the estimated population for Nuiqsut was 450, and over 90 percent of the population was Iñupiat (DOLWD 2016; NSB 2015a). In 2014, the estimated per capita income was $25,563; median household income was $94,375; and, median family income was $82,500. Just over three percent of Nuiqsut's population was estimated to be below the poverty level (DCCED 2016d). The local economy is subsistence-based; local government employs 55 percent of the total workforce; the private sector employs 46 percent; and, one percent is employed by state government (WHPacific 2015).

Air travel provides the only year-round access. Numerous airlines provide commercial, passenger, freight, and mail service to the community. There are four airports in Nuiqsut, two gravel airstrips, and two heliports. The Nuiqsut Airport provides commercial air and cargo services and is owned and operated by the NSB. ConocoPhillips Alaska owns the CD-3 Airstrip that transports company employees, contractors, and cargo. A 60-mile ice road reaches Nuiqsut approximately five to seven months per year from Deadhorse and Prudhoe Bay, which are connected to the Alaska road system via the Dalton Highway. Additional trails connect Nuiqsut to Anaktuvuk Pass (140 miles) and Atqasuk (150 miles). Snowmobiles and ATVs are commonly used for local transportation (DCCED 2016d).

The NSB school district operates the Trapper School which provides education from early childhood through grade 12. In addition to providing education services for children in Nuiqsut, the school district provides a number of services including bus service for students, an early childhood education program for three- and four-year old children, Inupiaq classes from the early childhood education level through eighth grade that is also open to students in other grade levels, and a culture camp each fall (NSB 2015c).

4. Prudhoe Bay

Prudhoe Bay is an unincorporated census designated place located in the NSB mainly utilized as a large work camp for the oil industry. All residents are employees of oil-drilling or oil-production and support companies and many work long consecutive shifts. Living quarters and food are provided to the workforce, and there are several recreational facilities (DCCED 2016e).

Before 2010, employees at remote work sites throughout the NSB were not counted in census surveys, which explains the significant increase in population estimates from five residents in 2000 to 2,174 residents in 2010. The population estimate of 2,174 residents has stayed the same between 2010 and 2015 (DOLWD 2016). Over 85 percent of Prudhoe Bay's population is white and eight percent is Alaska Native or American Indian. Per capita income was estimated to be $101,242, and approximately four percent of the population was estimated to be below poverty level (DCCED 2016e).

Prudhoe Bay is accessible year-round by both road and air travel, but air travel is the primary means of public transportation to the North Slope. There are four airports in the Prudhoe Bay area;

two are state owned, and two are privately owned and operated. The state owned and operated Deadhorse Airport is served by a variety of aircraft and can accommodate a Boeing 737 jet aircraft. The Deadhorse Airport is used primarily for commercial air and cargo service. The state also owns a heliport located at Prudhoe Bay. The Kuparuk River unit airstrip is a 5,000-foot by 100-foot private gravel airstrip owned and operated by Shared Services Aviation, providing scheduled flights several times per week for ConocoPhillips Alaska, Inc. and BP employees, contractors, and cargo. The Northstar Heliport is owned by BP Exploration, Alaska. The Dalton Highway is used year-round to haul cargo to the North Slope. There are no services beyond Prudhoe Bay and the highway is hazardous during winter months (DCCED 2016e).

5. Kaktovik

Kaktovik is located on the north shore of Barter Island, between the Okpilak and Jago Rivers on the Beaufort Sea coast. The area encompasses 0.80 square miles of land and 0.20 square miles of water (DCCED 2016b). Kaktovik is the easternmost village in the NSB, 70 miles west of the Canadian border, 120 miles east of Prudhoe Bay, and 310 miles east of Utqiaġvik. The City of Kaktovik incorporated in 1971. The City of Kaktovik is a second-class city within the NSB, and a seven-person city council provides local governance. The city is managed by the Mayor, who is also a member of the council (NSB 2015b).

The Native Village of Kaktovik is federally-recognized. It was established under authority of the Indian Reorganization Act (IRA) of 1934. The Native Village of Kaktovik is a member of the ICAS, the regional Native tribal government also recognized by the federal government (NSB 2015b).

In 2015, the estimated population for Kaktovik was 244, and over 88 percent of the population was Alaska Native or American Indian (DOLWD 2015b, 2016). The isolated village has maintained traditions and its primary subsistence resources are caribou, sheep, bowhead whale, fish, and waterfowl (NSB 2014). In 2014, the estimated per capita income was $19,605, median household income was $47,188, and the median family income was $77,500. Over 17 percent of Kaktovik's population was estimated to be below the poverty level (DCCED 2016b). Local government is the main industry in Kaktovik employing over 73 percent of the total workforce. The construction industry is the second largest employer at just over 10 percent of the workforce (DOLWD 2015b).

Air travel provides the only system for year-round access to Kaktovik. The Barter Island Airport is owned by the USAF and operated by the NSB. As of 2015, a new airport and runway were being constructed at the southern end of the island. USAF also owns and operates the private airstrip and heliport at the Bullen Point Air Force Station 64 miles east of Kaktovik. Aviation not only serves as a crucial link for passengers and cargo, but it is also the primary means by which Kaktovik residents receive mail. In addition to air transportation, marine transportation provides seasonal access to Kaktovik. Barges deliver cargo to the community during the summer (DCCED 2016b).

The NSB school district operates the Harold Kaveolook School which provides education from early childhood through grade 12. The school has experienced a continued decline in enrollment, serving 88 students in 2000, 56 students in 2010, and 51 students in 2012 (NSB 2015b).

6. Anaktuvuk Pass

Anaktuvuk Pass is located at 2,200 feet elevation on the divide between the Anaktuvuk and John Rivers in the central Brooks Range. Anaktuvuk Pass is located on a historic caribou migration route and is the last remaining settlement of the Nunamiut, the inland northern Iñupiat. The area encompasses 4.80 square miles of land and 0.10 square miles of water (DCCED 2016a; WHPacific 2015). Anaktuvuk Pass is 250 miles southeast of Utqiaġvik, and 250 miles northeast of Fairbanks. Anaktuvuk Pass is outside of the southern boundary of the Sale Area, but residents use the Sale Area for subsistence. The City of Anaktuvuk Pass originally incorporated as a fourth-class city in 1959, and incorporated as a second-class city in 1971. The City of Anaktuvuk Pass is managed by the Mayor, and a seven-person city council provides local governance. The Mayor is also a member of the council (DCCED 2016a; WHPacific et al. 2016).

The seven-member Nagsragmiut Tribal Council governs the Village of Anaktuvuk Pass, a federally-recognized tribe established under authority of the Indian Reorganization Act (IRA) of 1934. The Nagsragmiut Tribal Council is a member of the ICAS regional tribal government (WHPacific et al. 2016).

In 2015, the estimated population for Anaktuvuk Pass was 375, and over 83 percent of the population was Alaska Native or American Indian. The economy is subsistence based, harvesting caribou, fish, birds, and berries (DCCED 2016a; WHPacific 2015; WHPacific et al. 2016). In 2014, the estimated per capita income was $18,487; median household income was $52,000; and, median family income was $70,000. Over 15 percent of Anaktuvuk Pass's population was estimated to be below the poverty level (DCCED 2016a). Local government is the main industry in Anaktuvuk Pass, employing nearly 75 percent of the total workforce 2015 (DOLWD 2015a).

A gravel airstrip is owned and operated by the NSB and provides Anaktuvuk Pass with year-round access. Several airlines service the community, providing passenger, freight, and mail service. There are approximately eight miles of developed, gravel roads in Anaktuvuk Pass and approximately three miles of trails leading to the subsistence/recreation area north of the village. While there are no permanent roads leading to Anaktuvuk Pass, cargo has historically been transported in the winter via an ice road that connects to the Dalton Highway (WHPacific et al. 2016).

The NSB school district operates the Nunamiut School which provides education from pre-kindergarten through grade 12. Including preschool students, enrollment at the Nunamiut School averaged 87 students, with a low of 67 students during the 2003/2004 school year and a high of 104 students during the 2012/2013 school year. In addition to providing education services for children in Anaktuvuk Pass, the school district provides several student services including bus service, sports programs, and academic and extracurricular clubs and activities. The school district also operates an early childhood education program for three and four-year old children, Inupiaq classes, and a culture camp each fall. Iḷisaġvik College maintains a satellite computer station at the NSB Village Coordinator's Office that offers a variety of online courses for community residents (WHPacific et al. 2016).

E. Historic and Cultural Resources

Numerous sites across the North Slope containing sod houses, graves, storage pits, ice cellars, bones, and relics attest to the historical use and presence of Iñupiat and Western people in the Sale Area. Historic and cultural resources can include a range of sites, deposits, structures, ruins, buildings, graves, artifacts, fossils, and objects of antiquity which provide information pertaining to the historical or prehistoric culture of people in the state, as well as to the natural history of the state.

Historic and cultural sites include those identified in the Alaska Heritage Resources Survey (AHRS), the National Register of Historic Places, the NSB Traditional Land Use Inventory (TLUI), by the Commission on Iñupiat History, Language and Culture, and sites identified in other published studies. These databases are not exhaustive and are continually being updated with both new and revised information. The AHRS and TLUI are comprised of restricted access documents and specific site location data will not be published in this finding or distributed to others.

The AHRS database indicates that there are over 300 reported cultural resource sites within the Sale Area. At least four of these sites have been included in the National Register of Historical Places. The resource types include paleontological sites, prehistoric sites, Russian-era occupation sites, and early 20th century era sites. The historical and archeological record of the Sale Area continues to evolve as natural and human disturbances damage or destroy known sites while revealing new, undocumented sites in the process. Only a small portion of the state has been surveyed for cultural resources and lessees are advised that previously unidentified resources may be located within the Sale Area.

F. Climate

The North Slope climate is characterized as a northern polar climate dominated by a lack of sunlight in the winter and long days in the summer. Winters are long and cold, summers are short and cool. The Sale Area has one of the harshest environments in North America, with relatively little precipitation. Monthly precipitation is fairly uniform, with slightly less in May and more in July and August. Streams and lakes are frozen for much of the year because of the long winter. Snow cover is common from October through May. Summers, while short and relatively cool near the coast, are longer and warmer inland. Surface winds along the Arctic coast average 9 to 15 miles per hour, with occasional intense storms generating winds more than 70 miles per hour. Winds are predominately from the northeast, although the strongest winds come from the west. September and October are the windiest months on the coast, which coincide with the maximum amounts of open water (Wendler et al. 2010). The three-month ice-free season is critical to biological productivity.

The onset of snowmelt and subsequent runoff often begins earlier in the foothills than in the rest of the area and moves north as the summer season progresses. Freeze-up usually begins first on the coastal plain and proceeds southward. Winters are severe, forcing many species to migrate south. The North Slope climate is strongly influenced by the continental and marine environments, with the marine influence strongest on the coast and in the summer and diminishing gradually inland. Precipitation also varies east to west, with lands to the east tending to be wetter (Wendler et al. 2010; Searby and Hunter 1971).

While temperature varies in different parts of the Sale Area, the annual mean temperature is approximately 12 °F. The average maximum temperature at Umiat is about 22.5 °F, and the average minimum temperature is 1.8 °F. On the Beaufort Coastal Plain, temperatures fall below freezing between October and May. February is the coldest month with an average temperature of minus 17 °F, and July is the warmest month with an average temperature of 53 °F. Extreme temperatures can range from minus 56 °F to 78 °F. In the Brooks Range and Foothills areas, the average January temperature is minus 21 °F, and the average summer temperature is about 55 °F (Wendler et al. 2014; Zhang et al. 1997; URS Corporation 2005).

Temperature and precipitation records from 1949 to 2014 show annual and seasonal mean temperature increases throughout Alaska. The average temperature increase in Alaska from 1949 to 2014 was 3.0 °F, although the temperature changes varied from one climactic zone to another as well as seasonally. Across the North Slope, change in temperature has been more pronounced. An analysis of data from the same 65-year period from 1949 to 2014, showed the mean annual temperature increased by 4.9°F, with much of that change occurring between 2006 and 2011 (ACRC 2017; Clement et al. 2013). Tables 3.1 and 3.2 illustrate the differences in mean temperature and precipitation over a 30-year period between Prudhoe Bay, near the coast, and Umiat, at the southern edge of the Sale Area (WRCC 2016a, b).

Table 3.2.—Temperature and precipitation means for Prudhoe Bay (°F) 1981–2010.

Normal	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean minimum	-22.4	-24.0	-20.7	-5.2	18.1	32.9	39.6	36.7	29.3	10.8	-8.5	-17.3	5.9
Mean	-16.4	-17.0	-13.8	2.1	22.9	38.9	46.4	43.4	34.2	16.2	-3.3	-10.8	12.1
Mean maximum	-10.4	-10.0	-6.9	9.4	27.8	45.0	53.1	50.0	39.1	21.7	1.9	-4.3	18.2
Mean precipitation	0.16	0.10	0.14	0.09	0.07	0.40	0.68	1.07	0.62	0.33	0.18	0.20	4.04

Source: Western Region Climate Center 2014

Table 3.3.—Temperature and precipitation means for Umiat (°F) 1981–2010.

Normal	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean minimum	-30.7	-29.8	-29.0	-9.7	16.8	37.0	41.8	36.2	26.3	3.3	-16.2	-26.2	1.8
Mean	-21.3	-20.2	-16.9	2.4	26.5	49.2	55.0	47.9	35.0	11.5	-8.5	-16.5	12.2
Mean maximum	-11.9	-10.7	-4.8	14.5	36.2	61.4	68.3	59.5	43.6	19.7	-0.8	-6.9	22.5
Mean precipitation	0.38	0.19	0.24	0.24	0.05	0.33	0.76	0.95	0.31	0.56	0.39	0.41	4.81

Source: Western Region Climate Center 2014

The average global temperature of the earth has increased by approximately 1.4 °F since 1880, with the greatest increase occurring since 1975 at a rate of approximately 0.27 °F to 0.36 °F per decade. The global temperature record represents an average over the entire surface of the planet because temperatures vary significantly by region and shifts in temperature did not occur uniformly across all regions. Global temperature mainly depends on how much energy the planet receives from the sun and how much energy it radiates back into space. Whereas, local or regional temperatures fluctuate substantially due to predictable cyclical events, like night and day, summer and winter, and variable, sometimes hard-to-predict, wind and precipitation patterns (NASA 2017; NRC 2015). Taken in isolation, local or regional temperatures generally, do not provide a complete representation of global climate change historically or provide a sound basis for predicting future changes on a global scale. However, the physical changes related to increasing temperatures include melting permafrost, sea ice, and glaciers are more evident and have generally occurred faster in the Arctic than any other region (NRC 2015; Smith et al. 2017).

The greater rate of temperature increase in the Arctic versus the global increase is referred to as Arctic amplification. Arctic amplification is driven by a positive feedback loop that can amplify the initial temperature change, causing further warming, and has been found in past warm and glacial periods as well as in historical observations (Lea 2015; Melles et al. 2012; Pithan and Mauritsen 2014). Feedback effects associated with temperature, water vapor, and clouds have been suggested to contribute to amplified warming in the Arctic, but the surface albedo feedback, the increase in surface absorption of solar radiation when snow and ice retreat, is often cited as the main contributor. However, Arctic amplification has been documented in models without snow and ice cover, and contemporary climate models show the largest contribution to Arctic amplification comes from temperature feedbacks, as the surface warms, more energy is radiated back to space in low latitudes (the tropics), compared with the Arctic. In short, the difference in temperature between the upper and lower atmosphere dictates where warmer air is trapped causing the near surface atmosphere to warm more in the Arctic than in the tropics (Pithan and Mauritsen 2014). Evidence of extreme Arctic amplification, greater than present day, has been found in studies of the geologic record from the Arctic spanning the last 5.3 million years. Studies indicate that the Arctic climate during the Pliocene was approximately 14.4 to 34.2 °F warmer than today, depending on location and season, and approximately 3.6 to 5.4 °F warmer globally than pre-industrial conditions (Brigham-Grette et al. 2013; Lea 2015; Melles et al. 2012). This extreme warmth coincided with atmospheric CO_2 levels similar to present day values of approximately 400 parts per million, suggesting extreme amplification of positive climate feedbacks in the Pliocene (Brigham-Grette et al. 2013; Lea 2015).

In the Arctic, where much of the social and economic activity is connected to the presence and persistence of permafrost, snow, and ice, the effects of climate change may extend beyond physical and ecological processes. Physical changes related to increasing temperatures such as melting sea ice and glaciers, permafrost degradation, and erosion, are often part of an interrelated process. Melting freshens ocean waters causing changes in salinity and sea-level rise, while a reduction in seasonal sea ice cover opens vast stretches of ocean, allowing greater storm surges to occur. Sea-level rise, storm surges, permafrost thaw, and slumping lead to stronger storms that can cause coastal erosion and inundation of low-lying areas. Changing conditions may cause wildlife ranges to shift, while the increased growing season may allow new species and vegetation to establish along northern latitudes. Fisheries may be enhanced. There may be an increase in vessel traffic in Arctic waterways and greater access to natural resources, bringing new ports, roads, pipelines, and jobs (Smith et al. 2017).

G. Natural Hazards

A natural hazard is a natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Natural hazards can be classified into several broad categories: geologic hazards, hydrologic hazards, meteorological or atmospheric hazards, and biological hazards (Holmes et al. 2013). Changes in climate can alter natural processes and could increase the magnitude and frequency of certain types of geologic hazards including avalanches, floods, erosion, slope instability, thawing permafrost, and glacier lake outburst floods. If these hazards are not properly addressed, they could have a damaging effect on Alaska's communities and infrastructure, as well as on the livelihoods and lifestyles of Alaskans (DGGS 2017). Natural hazards may impose constraints on oil and gas exploration, development, production, and transportation activities; and should be considered before any siting, design, and construction of facilities. Natural hazards associated with development that are inherent to the arctic environment include permafrost thawing, channel flooding and erosion during spring break up, and shoreline impacts.

Major engineering problems arise in areas underlain by permafrost containing poorly drained fine-grained sediments. These sediments contain large amounts of ice, and when disturbed, a change in the thermal balance causes the ice to melt. Thawing produces excessive wetting and plasticity, making the sediments unstable which results in frost heaves, slumping, and subsidence of the ground surface. These processes and cycles of freezing and thawing in the active layer can cause extensive damage to building foundations and other facilities, roads, and airstrips. Design criteria for pads and structures must consider appropriate measures to insulate the soils to avoid introducing heat into the permafrost. Similarly, lessees must ensure there is adequate snow cover and soil freezing before starting winter tundra travel to avoid damaging the vegetation in a manner that will accelerate thawing of permafrost.

Location and design criteria for pads, roads and stream crossings need to be considered both for the magnitude of flood events and the height of floodwater during spring breakup. The height of water during a given flood event is a function of the amount of snow and ice in the channel as breakup begins, and the presence of ice jams that may form as the channel ice begins to move downstream. If the height of floodwater is underestimated, pads, roads, and other structures may be inundated during breakup. Design criteria for road and pipeline stream crossing also need to account for impacts from ice blocks as they are transported downstream during breakup conditions. Channel ice that is detached from the channel bottom as spring breakup occurs can cause damage to under-designed structures such as bridges, culverts and pipeline supports at stream crossings.

1. Faults and Earthquakes

The Sale Area is situated adjacent to the transition between two major geologic structures, the Colville Basin and the Barrow Arch. Formation of the Colville Basin, Barrow Arch, and the associated Brooks Range was initiated during mid-Cretaceous compression of the Arctic Alaska Plate, produced by rift-zone expansion in the marine basin bordering the plate to the north. The resulting deformation formed the Brooks Range thrust-fault belt and the foreland Colville Basin and Barrow Arch (Moore et al. 1994). Present day seismic activity and deformation of Quaternary sediment evidence the continuation of mountain building in the Brooks Range. Although Alaska is seismically active, the North Slope has not experienced an earthquake exceeding a magnitude of 5.3 since 1968. Surface faults have been mapped throughout the central North Slope, including high-angle faults, basement-involved normal faults, listric growth faults, and north-dipping gravity faults. Locally, two or more types may occur in close proximity to each other.

High-angle faults exist along the Barrow Arch extending into Harrison Bay. Along the Barrow Arch, they are related to the basement tectonics of the Arctic Platform, while in Harrison Bay they offset the Tertiary and older units. Displacement of Pleistocene or Holocene sediments has not been documented and there has been no recent seismicity associated with these faults. Thus, differential movement along these faults seems to have ended prior to the beginning of the Quaternary period (Craig and Thrasher 1982).

In contrast to the western Beaufort shelf off Alaska, the Camden Bay area is still seismically active. This region is located at the northern end of a north-northeast trending band of seismicity that extends north from east-central Alaska. Since monitoring began in 1978, many earthquakes, ranging from magnitude one to over five, have been recorded in this area, with most events clustering along the axis of the Camden anticline. The largest earthquake recorded in the area was a magnitude 5.3 event approximately 18 miles north of Barter Island in 1968. In this region, the Tertiary and Quaternary strata dip away from and are truncated at the top of the Camden anticline, indicating that it has been growing in recent geologic time. The faults in this region trend northwest-southeast, parallel to the hinge line and as they approach and intersect the axis of the Camden anticline, they offset progressively younger strata. This suggests that these faults are older hinge line-related structures that were reactivated in late Tertiary and Quaternary by the uplift of the Camden anticline (Page et al. 1991).

North of the Sale Area on the outer Beaufort shelf and upper slope, seaward of the 50 to 65 meter isobaths, are gravity faults related to large rotational slump blocks (Moore et al. 1994 citing Grantz and Dinter 1980; Grantz et al. 1982). South of these slumps, which bound the seaward edge of the Beaufort Ramp, these faults have surface offsets ranging from 50 feet to more than 225 feet high. Studies have inferred that these faults have been active in recent geologic time based on the age of the faults and therefore pose a hazard to bottom-founded structures in this area. Large-scale gravity slumping of the blocks here could be triggered by shallow-focus earthquakes centered in Camden Bay or in the Brooks Range (Moore et al. 1994 citing Grantz et al. 1982).

Most of the seismicity in the region is shallow (less than 20 miles deep), indicating near-surface faulting. Between 2008 and 2016, there were 59 recorded earthquakes in the Sale Area ranging from magnitude 1.0 to 4.2. Recent significant events include one magnitude 5.0 earthquake just south of the Sale Area in the North Slope Foothills in 2010, and three magnitude 4.0 earthquakes approximately 60 miles south of Prudhoe Bay, one in 2008 and two in 2013 (USGS 2017).

Studies estimate a 10 percent probability of exceeding 0.07 g[3] earthquake-generated peak ground acceleration in bedrock during a 50-year period in the Sale Area. For comparison, peak ground acceleration in Anchorage during the 1964 earthquake was estimated at 0.16 g. Ground accelerations are likely to be higher in parts of the Sale Area that are underlain by thick, soft sediments, than in bedrock due to amplification. However, thick localized permafrost may cause the

[3] Gravitational acceleration. One g equals an acceleration rate of 32 feet per second.

earthquake response of sediments to be more like bedrock, which would limit amplification effects and would also tend to prevent earthquake-induced ground failure, such as liquefaction. (Wesson et al. 2007; Boyd et al. 2008). Because of the periodic presence of sea ice along the Beaufort Sea coast, consideration should be given to the combined effects of sea ice–earthquake interactions on any potential infrastructure in this region. Studies suggest that earthquake load may be magnified by ice-structure interaction during a seismic event (Kato and Toyama 2004; Dong et al. 2012).

2. Permafrost

Permafrost is defined as ground (soil and rock as well as included ice and organic matter) that remains at or below 32°F for at least two consecutive years and can be found in both unconsolidated sediment and in bedrock. The mean annual temperature of permafrost in its stable thermal state is lowest at the permafrost table and increases with depth in accordance with the geothermal gradient. Seasonal freezing in the permafrost region is often two-sided, occurring both downwards from the surface and upwards from the underlying perennially-frozen material (French and Shur 2010). Permafrost underlies most land surfaces in the Arctic, including the Sale Area, varying from a few feet to several hundred feet thick, depending on its thermal history (Frederick et al. 2016). Permafrost in the Sale Area is termed present permafrost and considered continuous, occupying 90 to 100 percent of the land area with unfrozen areas generally present only below rivers or lakes (Martin et al. 2009). Along the Beaufort Sea on the coastal plain, permafrost extends as much as 2,000 feet below the surface, and most permafrost temperatures at the depth of zero annual amplitude vary between 14 to 23°F (Frederick et al. 2016 citing Kanevskiy et al. 2013)

Present permafrost is either in equilibrium with current climate, or aggrading or degrading under prevailing climate conditions. Permafrost may also be relict, or ancient, having formed under conditions that no longer exist and which is now preserved under present environmental conditions (Kanevskiy et al. 2016). Most of the permafrost in the Sale Area formed tens of thousands of years ago during the late-Pleistocene, when the mean annual air temperature was much colder than present day. It can be argued that nearly all present permafrost is relict because climate has warmed approximately 4 to 7°F in the last 150 years following the Little Ice Age, but permafrost in the Sale Area is continually adjusting to changes in the thermal regime (Frederick et al. 2016; DGGS 2011).

Changes in permafrost are an important indicator of climate change. During the fourth quarter of the 20th century, permafrost temperatures warmed across northern Alaska from Utqiaġvik to the Alaska–Canada border coincident with a statewide increase in air temperatures that began in 1977 (Jorgenson et al. 2010; Wendler et al. 2014). From Prudhoe Bay, the warming extended south through the Brooks Range. The magnitude of the warming at the surface of the permafrost (through 2003) averaged 5°F west of the Colville River, ranged from 5–7°F for the Beaufort Coastal Plain at Prudhoe Bay, and somewhat less at Utqiaġvik and Barter Island and to the south (DGGS 2011 citing Osterkamp 2003). The warming of air temperatures was seasonal, greatest during winter, October through May, and least during summer, June through September. Snow covers were thicker than normal during the late 1980s and the 1990s, which contributed to the permafrost warming. At the turn of the century, permafrost temperatures showed that permafrost warming had slowed in the Prudhoe Bay area and to the south (DGGS 2011 citing Osterkamp 2005, 2007).

Permafrost is commonly overlain by a surface layer of ground, soil, or unconsolidated sediment. The surface layer, called the active layer, typically thaws and re-freezes each year. The active layer is critical to the ecology and hydrology of permafrost terrain, as it provides a rooting zone for plants and acts as a seasonal aquifer for near-surface ground water (Panda et al. 2016). The thickness of the active layer varies from year to year and from locality to locality, depending on controls such as ambient air temperature, slope orientation and angle, vegetation, drainage, snow cover, soil and/or rock type, and water content.

Depth of permafrost is variable and depends on the amount of solar radiation, aspect, thickness and duration of snow cover, material properties, altitude, and latitude (Pastick et al. 2015). Permafrost thickness has been measured from numerous wells north of the Sale Area where it generally thins from east to west (Liu et al. 2010). East of Oliktok Point, it has been measured to be more than 1600 feet thick, whereas west of the Colville River it has been measured to be 980 to 1,300 feet thick (Clow and Lachenbruch 1998; Osterkamp et al. 1985). Permafrost thickness along the boundary between the Beaufort Coastal Plain and the Brooks Range foothills varies from 650 to 980 feet (Kanevskiy et al. 2016). At Umiat, the depth of permafrost has been measured to be more than 1,000 feet (Clow and Lachenbruch 1998).

The form and texture of ground ice within permafrost also varies greatly. Ground ice forms include thin lenses of ice, layered ice, reticulated vein ice, and ice wedges as big as 6 to 13 feet long and 10 to 16 feet deep (Panda et al. 2016). Ice wedges and polygonal surface features (i.e., ice-wedge polygons) are typical of permafrost landscapes and found throughout the Sale Area. Ground ice forms during winter months when thermal contraction cracks the frozen ground, much like the surface of sunbaked, dried mud. During the warmer, wetter season, water infiltrates the cracks and refreezes. Consecutive freeze-thaw cycles cause the ice wedges to grow and expand, forming large polygonal features often clearly seen on the surface (Kanevskiy et al. 2016).

Though all permafrost can be affected by warming and thawing, the vulnerability and resilience of permafrost to climate warming is complicated by dynamically changing surface properties related to snow, vegetation, active layer thickness, surface water, groundwater, and soils. Thawing of ice-rich permafrost causes particularly strong feedbacks to ground surface stability, microtopography, hydrology, ecosystem function, and the carbon cycle. These dynamics can lead to both positive and negative feedbacks to permafrost stability, allowing permafrost to persist at mean annual air temperatures (MAATs) as high as 36°F along the southern margin of the permafrost and to degrade at MAATs as low as minus 4°F in the high Arctic (Jorgenson et al. 2010; Smith et al. 2010). For example, negative feedbacks from these interactions primarily related to vegetation succession can reduce mean annual soil temperatures by as much as 43°F. In contrast, surface water can raise temperatures at the water-sediment interface by as much as 50°F, rendering permafrost vulnerable to thawing (Jorgenson et al. 2010; Pastick et al. 2015).

Other processes also degrade permafrost and mobilize deep soil organic carbon. Soil removal and disturbances of the ground thermal regime triggered by fires, floods, and vegetation can result in rapid local degradation of permafrost by thermokarst or thermoerosion and result in uneven topography in the form of mounds and sink holes. The melting of excess ground ice, including segregated ice, ice wedges, and other massive ice bodies in permafrost, results in subsidence and water impoundment. Thermokarst lakes formed during the Holocene, the past 12,000 years, whose positive feedbacks accelerate subsidence and permafrost thaw, mobilize deeper permafrost-stored organic carbon and enhance greenhouse gas emissions (Pastick et al. 2015).

Many geologic hazards in permafrost regions are related to the changes in both the active layer and permafrost thickness related to seasonal and long-term temperature fluctuations, as well as to manmade ground disturbances and structures. Ground settlement occurs whenever a heated structure is placed on ground underlain by shallow, ice-rich permafrost, and proper engineering measures are not taken to adequately support the structure and prevent the structure’s heat from melting the ground ice. The degree of settlement is a function of the original thickness of the active layer, the increase in the active layer as it adjusts to the surface disturbance, and the thaw strain of the underlying permafrost (Jorgenson et al. 2010; Liu et al. 2010). In general, the magnitude of settlement depends on the nature and abundance of ice and the severity of the disturbance. Arctic lowland areas are particularly at risk for thaw subsidence because of the high volume of ground ice at the top of the permafrost (DGGS 2011). The potential for thaw settlement is least in areas of active river deposits and eolian sand and can be greater than three feet in areas of alluvial marine deposits (Kanevskiy et al. 2016). Such disturbances may make the surface unsuitable for many construction purposes.

In addition to settlement, seasonal freeze-thaw processes will cause frost jacking of unheated structures placed on any frost-susceptible soils unless the structures are firmly anchored into the frozen ground with pilings or supported by non-frost-susceptible fill (Combellick 1994). The depth of this layer of seasonal thaw is generally less than 3 feet below the surface and 6 feet beneath most active stream channels and is dependent on site-specific hydrological and geotechnical water crossing conditions (Panda et al. 2016). Borings along the Colville River, for example, show it remains thawed year-round (DGGS 2011). The frost susceptibility of the ground is highest in fine-grained alluvium, colluvium, thaw-lake and thermokarst deposits; moderate in alluvial-fan deposits and till; and lowest in coarse-grained floodplain deposits, alluvial terrace deposits and gravelly bedrock (Pastick et al. 2015).

Surface response to melting permafrost and seasonal ground ice is not uniform, and is related to the amount and type of ground ice and the interactions of slope position, soil texture, and hydrology (including snow cover), as well as vegetation and the effects of fire over time. The ice content of permafrost can vary significantly. It can be ice-rich, or it can contain practically no ice at all. Ice content is highest in fine-grained, organic-rich deposits and lowest in coarse granular deposits and bedrock (Frederick et al. 2016). In the Sale Area, ice content in the permafrost varies from segregated ice to massive ice in the form of wedges and pingos. Changes in the distribution of ice in soil pore space can impact sediment strength on both seasonal and long- term scales. Generally, soil strength is greater during the winter when soil water is frozen than during summer months when melting occurs (Jorgenson et al. 2010).

As a result, continued monitoring of permafrost stability, including water content and temperature variability of soils, and continued assessment of mitigation techniques are necessary. Frozen ground problems can be successfully mitigated through proper siting, design, and construction. Structures such as drill rigs and permanent processing facilities should be insulated to prevent heat loss into the substrate. Pipelines can be trenched, back-filled, and chilled (if buried) or elevated to prevent undesirable thawing of permafrost. In addition, Alaska Department of Natural Resources regulates winter travel across the tundra and authorizes travel only after determining that the tundra is sufficiently frozen and protected by ample snow cover so that the travel will not have major environmental effects such as permafrost degradation.

3. Erosion

The combined effects of rising sea level, declining sea ice, increasing summer ocean temperature, increasing storm power, and subsidence of coastal permafrost have had a notable effect on the rivers and coastline of the Sale Area. Wind and water are the forces driving erosion along Alaska's Arctic coast. While the erosion of coastal sediments occurs across daily, seasonal, and decadal to centurial timescales, the reworking of coastal sediments is condensed to the brief open-water period from mid-July to mid-September when wind-driven waves and ice blocks lap barrier island and mainland shores.

Patterns of coastal erosion relate to coastline elevation, orientation, geomorphology, sediment size, and permafrost nature. Erosion along arctic coastlines is exacerbated by thermal degradation of interstitial and massive ice. Thawing of ice-rich polygon centers and melting of massive ice wedges causes subsidence of the tundra surface along low-relief, protected coastlines. The subsequent ingress of seawater creates a drowned landscape, and significant rates of erosion are shown where these fine-grained, saturated soils are exposed to high-energy waves. A study of a 37-mile segment of the Alaskan Beaufort Sea coast revealed that mean annual erosion rates increased from minus 22.3 feet per year between 1955 and 1979, to minus 28.5 feet per year between 1979 and 2002, to minus 44.6 feet per year between 2002 and 2007 (Jones et al. 2009; Ping et al. 2011).

Adjacent to the Sale Area along the unprotected coastline of the Teshekpuk special use area, ground ice content exceeds 80 percent and a mosaic of thermokarst lakes and drained lake basins occupy 84 percent of the landscape (Martin et al. 2009; Jones and Arp 2015). Here, lake margins may be compromised by tapping from adjacent streams, lakes, or ocean, breaching from high lake levels, head ward gully erosion, or thaw slump formation. In some cases, lake drainage may occur catastrophically; for example, a nearly 200 acre lake was drained in 72 hours by the formation of a thermoerosional gully (Jones and Arp 2015). Most coastal habitat loss north of Teshekpuk Lake between 1985 and 2005 was a result of the degradation of permafrost affected by saltwater flooding of nearshore basins and channels. It is likely that Prudhoe and Pogik Bays were formed in this manner (Arp et al. 2010).

Areas of significant sediment aggradation along the Arctic Coast are found in the prograding deltas of the Canning, Shaviovik, Sagavanirktok, Kuparuk, Coville, Ikpikpuk, Topagoruk and Mead rivers (Hopkins and Hartz 1978). In those areas, the rate of progradation is very slow. The progradation rate of the Colville River delta was estimated to be 1.3 feet per year (Reimnitz et al. 1985). Sediment accumulates to a lesser and more localized extents as capes attached to mainland coasts, spits attached to most barrier islands, and as ebb and flood tidal deltas that are formed on the seaward and landward sides of barrier island inlets by the exit and entrance of tidewater. The longevity of these coastal features depends on the rate of sea level rise compared to the rate of continued sedimentary deposition. Some projections show that temperature increase in the arctic will increase the sedimentation rates to keep pace with the projected sea level rise (Martin et al. 2009).

Factors influencing erosion along the North Slope coastline also affect erosion along the region's rivers, although the driving forces (currents, waves with a short fetch) are somewhat different. Sediment cohesiveness, influenced by the degree and depth of seasonal frost, and permafrost, are important factors in determining river bank erodibility (Gatto 1984). High erosion rates occur along braided channels, which usually develop in areas composed of noncohesive sediment. In a study along the Sagavanirktok River, aerial photographs showed a maximum erosion rate of approximately 15 feet per year during a 20-year period. In this area, most of the erosion appeared to occur in small increments during breakup flooding and was concentrated in specific areas where conditions were favorable for thermo-erosional niching (Combellick 1994).

Erosion of stream banks results from thermal erosion, bank undercutting, high velocity flooding, and ice scour by broken river ice during spring breakup. Thermal erosion is a process of combined thermal and mechanical action that occurs when running water comes in contact with ice-cemented sediments, heat transfer causes the frozen soil to thaw quickly and removed simultaneously. As water comes into contact with ice cemented sediments, heat transfer causes the ice to melt. (Kanevskiy et al. 2016 citing van Everdingen 1998; Shur and Osterkamp 2007). Removal of thawed deposits constantly exposes the frozen face of the bluff, and results in the fall of large blocks of frozen ground, which ultimately disintegrate in water or on banks. Riverbank erosion in areas of ice-rich permafrost driven by the processes of thermal erosion and thermal denudation. There are three main stages in the process of riverbank erosion and stabilization: thermal erosion combined with thermal denudation, thermal denudation, and slope stabilization (Kanevskiy et al. 2016).

Thermal denudation, a suite of processes specific to erosion in the areas of ice-rich permafrost, involves thawing of exposed frozen soil on the surface of the bluff because of solar radiation and convective heat exchange between the cold surface and the air and the flow of water and sediment down the bluff. Thermal denudation starts on the frozen face of a bluff exposed by thermal erosion and continues for years and even decades after the termination of thermal erosion. Thermal denudation during active thermal erosion reduces the total rate of erosion because it reduces the size of blocks of frozen soil above niches, and as a result, decreases stresses in frozen ground and ice above niches and therefore increases the duration of time periods between block-fall events (Kanevskiy et al. 2016).

Rates of thermal erosion are greater than those of thermokarst, related to thawing of permafrost by heat conduction with accumulation of the thawed material over permafrost, and more effective than permafrost thawing in contact with standing water (Kanevskiy et al. 2016 citing Shur 1988).

Most of the modern Arctic coast and many riverbanks are affected by thermoabrasion of icy permafrost sediments. Permafrost coastline retreat rates sometimes exceed 65 feet per year (Jones et al. 2009). Erosion rates are likely to accelerate with permafrost warming, increased seawater temperatures, and reduced sea ice extent. In addition, thermal erosion causes mass wasting in gullies, retrogressive thaw slumps, and active layer detachment slides.

Erosion rates, river bank and shoreline stability, and the potential impacts of waves and storm surge must all be considered in determining facility siting, design, construction, and operations especially with recent studies indicating that the extent of seasonal ice-free seas in the Arctic has been increasing and could potentially result in increased rates of erosion along Arctic coastlines (Mahoney et al. 2007). Facility siting, design, construction and operation must also be considered in determining the optimum oil and gas transportation mode. Structural failure can be avoided by proper facility setbacks from coasts and river banks. Docks and road or pipeline crossings can be fortified with concrete armor, and by placing retainer blocks and concrete-filled bags in areas subject to high erosion rates, such as at the Endicott causeway breaches.

4. Flooding

Floods are influenced by the type of physiographic region drained, the size of the drainage area, and the frequency of the event due to seasonal snowmelt and ice jams. In the Sale Area, floods occur annually during spring breakup between May and early July along most of the rivers and many of the adjacent low terraces (Walker and Hudson 2003). The breakup cycle is the result of several factors including snow pack, sustained cold or warm temperatures, ice thickness, wind speed and direction, precipitation, and solar radiation.

When spring flow begins, water flows over the snow and ice in the channels. Flooding can extend for considerable distances beyond channels. Generally, flooding subsides as channel ice is carried downstream and out to sea. However, the formation of ice jams increase the height of floodwater, especially in downstream reaches and can cause catastrophic flooding. Some of the most damaging floods are associated with an above-average snowpack that is melted by rainstorms and sudden warming (Walker and Hudson 2003). The potential for riverine flooding should be assessed when designing and locating new facilities particularly around Nuiqsut.

Snowmelt flooding occurs annually in all North Slope rivers. For rivers in the Sale Area, snowmelt flooding nearly always produces the annual peak discharge. On some of the larger rivers, summer precipitation or late summer/fall snowmelt events have been observed to produce low magnitude floods. Ice jams during breakup can also influence or result in flooding.

Rarely do flood events occur along the Beaufort coastal plain that result from precipitation events. Intense, long periods of rainfall can cause general flooding and swollen streams. This is not a normal yearly occurrence because of the low precipitation in the Arctic; however, floods from August rains have been extensive (Selkregg 1975).

During late fall, storm surges often cause significant flooding and damage along coastal areas. In the fall, the sea ice may be far enough offshore that high winds can develop high waves and a storm surge tide that inundate coastal areas. Both Utqiaġvik and Kaktovik have experienced flooding and erosion during fall storms, and potential for flooding should be a factor when siting new facilities and housing.

In addition to seasonal flooding, many rivers along the coast are subject to seasonal icing prior to spring thaw. This is due to overflow of the stream or groundwater under pressure, often where frozen or impermeable bed sections force the winter flow to the surface to freeze in a series of thin overflows, or where spring-fed tributaries overflow wide braided rivers. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the flood-plain margin. These large overflows and residual ice sheets have been documented on the Sagavanirktok, Shaviovik, Kavik, and Canning Rivers (Combellick 1994).

Seasonal flooding of lowlands and river channels is extensive along major rivers that drain into the Sale Area. Thus, measures must be taken prior to facility construction and field development to prevent losses and environmental damage. Predevelopment planning should include hydrologic and hydraulic surveys of spring break-up activity as well as flood-frequency analyses. Data should be collected on water levels, ice floe direction and thickness, discharge volume and velocity, and suspended and bedload sediment measurements for analysis. Also, historical flooding observations should be incorporated into a geologic hazard risk assessment. All inactive channels of a river must be analyzed for their potential for reflooding. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

5. Mitigation Measures

Several geologic hazards exist in the Sale Area that could pose potential risks to oil and gas installations and are discussed above.

Detailed site specific studies may be necessary to identify any specific earthquake hazards for any specific site within the area. The risks from earthquake damage can be mitigated by siting onshore 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 for Alaska.

Before developing any kind of infrastructure, it is important to determine if permafrost is present. Potential hazards may be mitigated by incorporating careful evaluation, proper engineering, or avoidance of susceptible areas. Stream icings may also be a problem, but are highly localized hazards and may be mitigated by careful evaluation and avoidance of susceptible area.

Although geologic hazards could damage oil and gas infrastructure, measures in this best interest finding, regulations, and design and construction standards, are expected to mitigate those hazards. Mitigation measures in this finding address siting of facilities and design and construction of pipelines. A complete listing of mitigation measures is found in Chapter Nine.

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Chapter Four: Habitats, Fish, and Wildlife

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Chapter Four: Habitats, Fish, and Wildlife

This chapter considers and discusses the habitats and fish and wildlife populations of the Sale Area, as required by AS 38.05.035(g)(1)(B)(iii). This chapter is not intended to be an exhaustive examination of all habitats and fish and wildlife species of the Sale Area. The director has established the scope of this administrative review and finding and may address only the reasonably foreseeable significant effects of the proposed uses authorized by the disposal. The director has limited this review to the applicable statutes and regulations, and facts pertaining to the land, resources, or property known to the director or knowledge made available to the director during the administrative review that are material to the determination of whether the lease sales will best serve the interests of the state (AS 38.05.035(e)(1)(A)-(B)).

The Sale Area is contained within a large ecosystem identified as polar Arctic tundra. Polar Arctic tundra is generally distributed above the latitudinal tree line in Alaska. This area extends from the crest of the Brooks Range northward to the Arctic Ocean, and is known as the Arctic Slope. The Arctic Slope includes the north side of the mountains, northern foothills, and the flat coastal plain. Due to the region's high latitudinal position, it experiences less intense solar radiation and an exaggerated seasonal variation. It is the only true Arctic biogeographic province in the United States (ADF&G 2006).

Arctic tundra persists under cold air conditions originating off the permanent sea ice pack. This air has low moisture-holding capacity combined with minimal precipitation (ADF&G 2006). The Arctic tundra is represented by a low diversity of plant species and low plant biomass. These characteristics, combined with a short growing season, slow rates of growth, and vegetative reproduction, result in delayed recovery from disturbance (ADF&G 2006 citing Oceanographic Institute of Washington 1979).

A. Ecoregions

Ecoregions are areas of land and waters containing vegetation communities that share species and ecological dynamics, environmental conditions, and interactions that are critical for their long-term persistence. Ecoregions represent a unified mapping approach that blends traditional approaches with regionally specific knowledge and ecological goals, and are frequently used as a framework for studying ecosystem structure and function (Hoffman et al. 2013). The U.S. Geological Survey divides the North Slope into three ecoregions: the Beaufort Coastal Plain (BCP), the Brooks Foothills, and the Brooks Range. The Sale Area exists in two of the ecoregions, the BCP, and the Brooks Foothills (*See* figure 4.1). The identification of Alaska's ecoregions and associated maps are the product of a collaborative effort between the U.S. Forest Service, National Park Service, U.S. Geological Survey, The Nature Conservancy, and personnel from other agencies and private organizations (Gallant et al. 1995; Nowacki et al. 2001).

1. Beaufort Coastal Plain

The BCP is a windswept, treeless landscape comprised of periglacial features such as thaw lakes, marshes, and polygonal patterned ground (Trammell et al. 2015; Nowacki et al. 2001;

ADF&G 2006). Covering more than 19,000 square miles, the BCP is the northernmost ecoregion in Alaska (Martin et al. 2009). The coastal plain gradually extends southward from the shoreline approximately 30 miles into the foothills of the Brooks Range. The region is underlain by thick permafrost, except under large rivers and thaw lakes, and is over 2,000 feet deep at Prudhoe Bay (Martin et al. 2009). The presence of permafrost combined with little topographic relief prevents surface drainage resulting in saturated soils with thick organic horizons. Thaw lakes cover up to 50 percent of the BCP, and the entire region supports wetland communities (ADF&G 2006). The polygonal patterned ground forms from ice wedges that freeze within contraction cracks in the soil. Throughout the year, these cracks fill with water and snow, then freeze and expand. Freshwater lakes cover approximately 26 percent of the BCP (Trammell et al. 2015; Nowacki et al. 2001). Most major streams originate from other ecoregions to the south. Streams west of the Colville River are interconnected with lakes and tend to be sluggish and meandering, while those east of the Colville River are braided and build deltas into the Arctic Ocean. Streams originating in the BCP have the latest break-up and earliest freeze up and generally cease flowing by December. Some small streams will dry up completely in the winter (Martin et al. 2009). Anadromous Arctic cisco, broad whitefish, least cisco, and Dolly Varden overwinter in larger rivers and migrate to nearshore waters for the summer. The BCP supports large caribou herds and is an important calving area. Other important herbivores include muskoxen, lemmings, and Arctic ground squirrels, while important predators include Arctic foxes, gray wolves, and brown bears. Polar bears occasionally den on the coastal plain. The region is also important for breeding waterfowl, including a wide variety of shorebirds, ducks, geese, swans, and passerines (ADF&G 2006).

2. Brooks Range Foothills

Covering more than 37,000 square miles, the Brooks Range Foothills are characterized by gently rolling hills, and broad exposed ridges that form the northern flank of the Brooks Range. The Brooks Range Foothills stretch from the Chukchi Sea in the west to the Canadian border to the east (Martin et al. 2009). Narrow alluvial valleys and glacial moraines and outwash are interspersed among long linear ridges, buttes, and mesas made of tightly folded sedimentary rocks. Most of the surface is mantled with colluvial and eolian deposits. A dry polar climate dominates the land that is somewhat wetter and warmer than the BCP. Mixed shade-sedge tussock tundra is dotted with thickets of willow along rivers and small drainages (ADF&G 2006). The ecoregion is underlain by thick continuous permafrost. The Brooks Range Foothills have better defined drainage networks than the BCP, but the presence of permafrost creates soils that range from well-drained mineral substrates to saturated organic horizons. Though portions may be braided, most streams tend to be swift, with smaller streams drying up or freezing during winter. Some streams freeze solid to their bottoms, causing large aufeis deposits that last well into the summer and provide refuge for caribou from mosquitoes. Flooding and shifting is common during breakup of river ice. Predominate types of lakes in the region include glacial and oxbow lakes located along major streams (Martin et al. 2009; Trammell et al. 2015). The area is important to caribou, muskoxen, arctic ground squirrels, peregrine falcons, wolves, and brown bears (Nowacki et al. 2001).

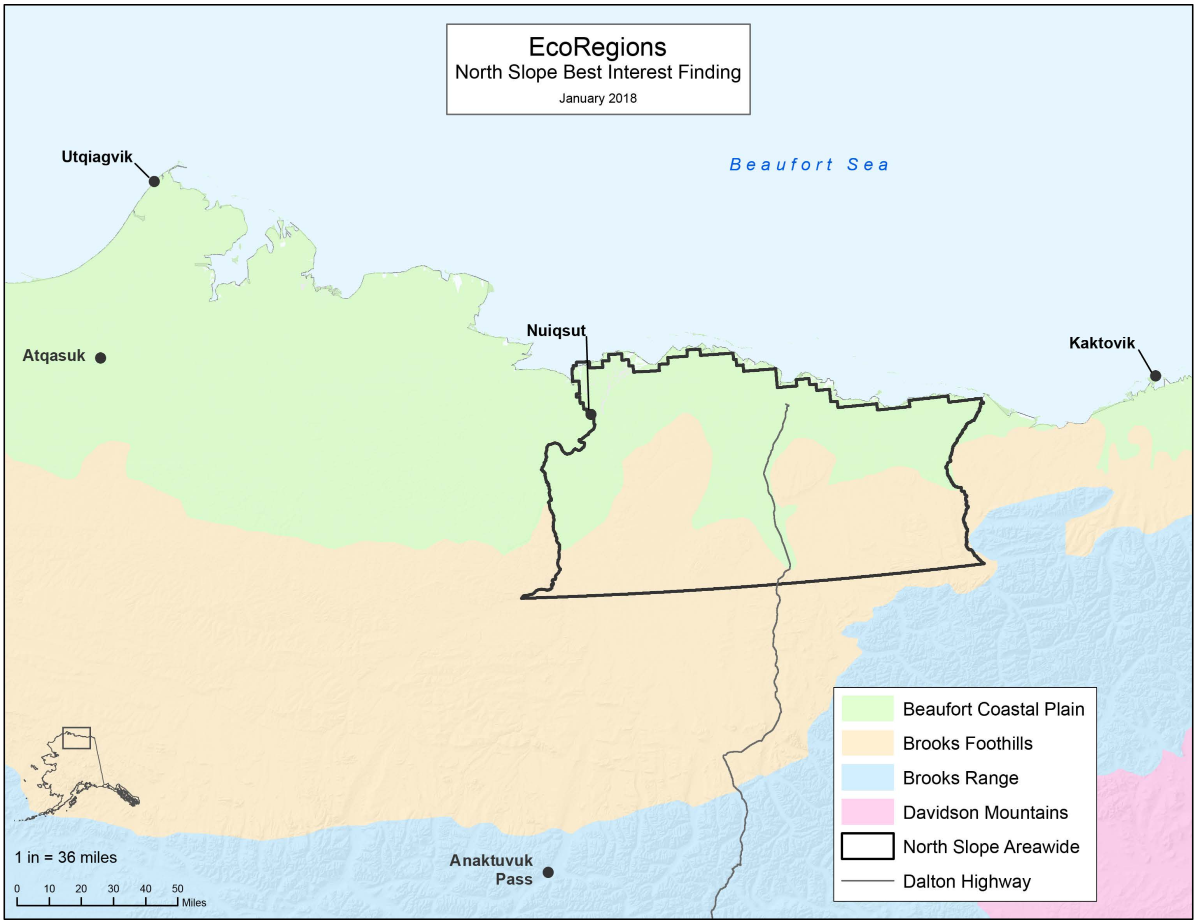

Figure 4.1.—Ecoregions in the Sale Area.

B. Habitats

The ecoregions of the North Slope Areawide include terrestrial, estuarine, wetland, and freshwater habitats that support the natural resources of the Sale Area. A variety of wildlife roam along the coastal plain and northern foothills of the Brooks Range. Freshwater streams and lakes, aquatic plants, wetlands, tussock meadows, and riverine corridors provide species higher up in the food chain with essential nutrition and shelter. Important fish and wildlife populations found in or adjacent to the Sale Area are discussed in Section C of this chapter.

1. Coastal Habitats

The Beaufort Sea coast is a dynamic environment. Characterized by lagoons with sandy barrier islands, exposed coast, deltas, and low-lying drained lake basins that occasionally flood because of storm surges, the Beaufort Sea coastline is greatly affected by sea ice, wind-driven waves and storm surges, surface water temperatures, coastal erosion and accretion, sedimentation by rivers and eroding coastal bluffs, and long-shore currents (Martin et al. 2009; National Research Council 2003). Coastal habitats are essential to a wide variety of fish, shellfish, seabirds, waterfowl, and marine mammals (ADF&G 2006).

In the intertidal zone, wave energy, substrate, tidal action, temperature, and salinity influence biota abundance. The three main types of rocky intertidal habitats include: exposed rocky shores with steeply dipping, vertical bedrock, with high to moderate wave energy; exposed wave-cut platforms with wave-cut or low-lying bedrock, with high to moderate wave energy; and, sheltered rocky shores with vertical rock walls, bedrock outcrops, wide rock platforms, and boulder strewn ledges, usually found along sheltered bays or along the inside of bays and coves.

Coastal habitats in and near the Sale Area are changing. The combined effects of rising sea level, declining sea ice, increasing summer ocean temperature, increasing storm power, increasing wave action, and subsidence of coastal permafrost have had a dramatic effect on the Arctic coastline of Alaska (Ping et al. 2011; Jones et al. 2009). A study of a 37-mile segment of the Alaskan Beaufort Sea coast revealed that mean annual erosion rates increased from minus 22.3 feet per year from 1955 to 1979 to minus 28.5 feet per year from 1979 to 2002, to minus 44.6 feet per year from 2002 to 2007 (Jones et al. 2009; Ping et al. 2011). Where habitat is not lost directly to the sea, subsidence, storm surge, and other factors contribute to salt water inundation of coastal habitats. The introduction of sediment and salts to coastal habitats may weaken or kill non-salt tolerant vegetation, which is then replaced by salt tolerant species (Jones et al. 2009; Pearce et al. 2012; Ping et al. 2011).

Warming temperatures have resulted in earlier snowmelt, lake ice thaw, and plant growth within the region (Pearce et al. 2012). Seasonal changes affect the distribution and composition of the biota. Spring and summer climates encourage ecosystem productivity. Detritus, decomposed organic matter, becomes a food source for filter feeders, which become food sources for other birds and fish in the intertidal community (ADF&G 2006).

Intertidal areas alternately exposed by rising and falling tides are often referred to as tidal mudflats. Arctic tidal mudflats receive freshwater from streams and rivers, and overland and subsurface flow during spring and summer runoff (Trammell et al. 2015 citing Kincheloe and Stehn 1991). Permafrost is present in most arctic tidal mudflats where it promotes inundation of surface water by restricting drainage (Trammell et al. 2015 citing Jorgenson et al. 2004 and 2009). Formed by unconsolidated deposits, the fine sediment comprising tidal mudflats is predominantly sourced from the large rivers and deltas that empty into the Beaufort Sea (Trammell et al. 2015 citing Hopkins and Hartz 1978). Tidal mudflats along exposed coastlines support little vegetation with up to 80 percent covered by bare mud and sand. Conversely, tidal mudflats that develop in sheltered lagoons and estuaries are larger, have a continuous cover of emergent vegetation, and support a greater diversity of plant and animal communities (ADF&G 2006). Tidal mudflats are a critical staging area for migratory birds, including snow geese, brant, and Steller’s eider.

1. Estuaries

An estuary is a partly enclosed coastal body of water that has a free connection with open sea, where fresh water from land drainage is mixed with seawater. Estuarine environments are defined by their salinity boundaries instead of geographic boundaries (ADF&G 2006; Dunton et al. 2006). Estuaries occur as bays at the mouths of rivers, marine waters behind barrier islands, and upstream in rivers and waterways to the limit of salt water intrusions. Estuaries are subject to tidal action. The largest estuary in the Sale Area is the Colville River estuary. The Colville River is the largest of three rivers draining into the North Slope. The other two are the Sagavanirktok, and the Kuparuk rivers (McClelland et al. 2014).

The mixture of fresh and salt water in the estuarine environment provides a unique yet important habitat for feeding and rearing fish, shellfish, waterfowl, marine mammals, and benthic invertebrates (ADF&G 2006; Dunton et al. 2006).

2. Barrier Islands and Lagoons

Barrier islands and lagoons form low-lying peninsulas or spits of accumulating sand or gravel across the mouths of bays, inlets, or other coastal embayments. This may be due to the transport of materials by ocean currents or wave action, or deposition from the outflow of streams and rivers. These unique and important habitats shelter the water in the protected lagoons while maintaining continuous or periodic exchanges of water with the sea. Barrier island lagoons contain a mixture of fresh and salt water, which often results in much more productive habitats than adjacent marine waters. However, abundance and distribution of biota are strongly influenced by cold climate. As a result, much of the biological use of lagoons near the Sale Area is highly seasonal (Truett 1983; Dunton et al. 2006).

In addition, barrier islands and lagoons accommodate vital molting and staging areas for waterfowl and shorebirds and feeding areas for birds, seals, and fish. Besides protecting coastal areas from scouring and wave erosion, barrier islands serve as nest habitats for birds, seal haul-outs and pupping areas, and as beach spawning habitat for some marine fish species (Truett 1983; ADF&G 2006).

3. Wetlands

Wetlands are vital habitats serving many needs. Characterized by poor soil drainage, wetlands are transitional zones between aquatic and terrestrial habitats, and are important in preserving biological diversity. Wetlands are used as nesting, rearing, molting, and staging areas for migratory birds. Wetlands serve as rearing areas for resident fish, and fresh water rearing stages of anadromous fish. Wetlands are also early spring feeding areas for bears and caribou, and sustain small mammal and furbearer populations (ADF&G 2006).

Wetlands can be hydrologically connected to rivers, streams and lakes (ADF&G 2006). They replenish and regulate stream flow, contribute to maintenance of water quality in lakes and streams, and provide important sources of organic nutrients to estuaries and coastal waters. Wetlands may be isolated or ephemeral in nature (Pringle 2003). There are primarily four types of wetlands identified in Alaska: bogs, grass wetlands, sedge wetlands, and salt marshes. Grass wetlands, sedge wetlands, and salt marshes may be found in the Sale Area and are discussed below (ADF&G 2006).

a. Grass Wetlands

Grass wetlands are composed of water-tolerant grass species that grow in clumps and tussocks. Wetter locations are generally hummocky. The soil substrate is generally organic or rich in minerals. Grass wetlands provide important wildlife habitat, perform as ground water recharge areas, and store storm and floodwaters which helps maintain minimum base flows critical for aquatic resources downstream (ADF&G 2006).

b. Sedge Wetlands

Sedge wetlands are typically inundated by water. Tall sedges, cottongrasses, rushes, bulrushes, and aquatic mosses may be present. Sedge wetlands may be found in very wet areas of floodplains, slow-flowing margins of ponds, lakes, streams, sloughs, and depressions of upland areas (ADF&G 2006).

c. Salt Marshes

Salt marshes are typically located at the mouths of rivers, behind barrier islands, coves, and spits of land. Tide flats may harbor salt marshes because low energy wave action and fine sediment deposits create elevated land where marsh vegetation establishes itself. The salt-tolerant vegetation grows between the mean high water and lower intertidal zone. Plant species include hairgrass, alkali grass, beach sandwort, sea arrowgrass, sea plantain, saltbrush, sand spurry and scurvey grass. Salt marshes provide spawning and nursery habitat for marine invertebrates and fishes such as ninespine stickleback. Fish species such as broad whitefish, Bering cisco, and capelin are also found there. Birds associated with salt marshes include Tule white-fronted goose, sandpipers, migrating geese, ducks, and shorebirds (Trammell et al. 2015; ADF&G 2006).

4. Rivers, Streams, and Lakes

Rivers are important to the ecosystem. Rivers and their tributaries provide protective plant cover, migratory routes, spawning and rearing habitats, and overwintering habitat support terrestrial wildlife along the riparian areas and serve as travel corridors (ADF&G 2006; McClelland et al. 2014; Pringle 2003). Major river corridors in the Sale Area include the Colville, Itkillik, Miluveach, Ugnuravik, Sakonowyak, Kuparuk, Putuligayuk, Sagavanirktok, Kadleroshilik, Shaviovik, Kavik, Staines, and Canning rivers. Riparian zones provide the interface between terrestrial and aquatic habitats, and like all edge habitats, they support a wide diversity of wildlife. Riparian zones also filter sediment, reduce the effects of the wind, regulate water temperature, and stabilize stream banks. Moose, bear and other mammals use these waterbodies and their riparian zones. Waterfowl and resident birds use the lakes and ponds for feeding, staging, and resting areas. Birds and wildlife forage, breed, and nest here (ADF&G 2006, 2016f). During the winter when many rivers freeze, the Colville and Sagavanirktok River deltas act as overwintering habitats for some species such as the Arctic cisco (Brown 2008).

Like other North Slope rivers, the Colville discharges fresh water into the Beaufort Sea, forming a zone of warmer brackish water along the coast. This zone is an important factor affecting the distribution and abundance of all Beaufort Sea fish because of its importance to amphidromous and anadromous species for feeding and migrating (ADF&G 2006).

Clearwater rivers and streams have high clarity and low turbidity unlike glacial water systems. Compared to glacier fed rivers, these waterways have narrower channels, low sediment loads, stable, well-defined banks and beds, and increased habitat complexity. Some lakes in the Colville delta, called tap lakes, are connected to the river by narrow channels. These channel connections allow water levels in these tapped lakes to fluctuate with changes in coastal water level. This may result in barren or partially-vegetated and often salt-affected shorelines (Johnson et al. 2013). Many lakes and streams also freeze to the bottom during winter. However, upwelling areas in ground water fed streams and perennial spring pools provide winter habitats for freshwater fish, particularly in the Arctic, where ground water sources are dominant throughout the year. Additional winter habitats for freshwater aquatic species can be found where spring fed streams, deep pools of large rivers, and deeper lakes are connected to rivers (ADF&G 2006).

Riparian vegetation along small streams and rivers benefit fish by providing shade, temperature control, organic debris, low velocity refuges during high runoff, and bank stabilization. Riparian habitat also provides food for fish directly through insects falling into the water and indirectly through detrital food web (Colin and Jamieson 2001). In Alaska, the most common detritus comes from dead plant material, which makes up to 90 percent of the organic matter supporting headwater stream communities (ADF&G 2006).

5. Designated Habitat Areas

There are six federally-designated habitat areas on the North Slope: the Arctic National Wildlife Refuge (ANWR), the Colville River Special Area (CRSA), the Teshekpuk Lake Special Area, the Peard Bay Special Area, the Kasegaluk Lagoon Special Area, and the Utukok River Uplands Special Area (*See* figure 4.2). There are no designated habitat areas within the Sale Area. Portions of ANWR and CRSA are immediately adjacent to the Sale Area and discussed below.

Extending along the entire eastern boundary of the Sale Area, ANWR was originally established as the 8.9-million-acre Arctic National Wildlife Range in 1960 by Public Land Order 2214 for the purpose of preserving unique wildlife, wilderness, and recreational values. In 1980, the Alaska National Interest Lands Conservation Act added 9.1 million acres of adjoining public land to the original designation, and renamed the area as ANWR. Currently, ANWR includes more than 19 million acres, and is managed by the U.S. Fish and Wildlife Service (USFWS) which works to conserve animals and plants in their natural diversity, ensure a place for hunting and gathering activities, protect water quality and quantity, and fulfill international wildlife treaty obligations (USFWS 2013).

Sharing portions of the western boundary of the Sale Area, the CRSA is approximately 2.44 million acres, and is located entirely within the boundary of the National Petroleum Reserve-Alaska (NPR-A) (BLM 2008b). The CRSA was designated in 1977 to protect nesting and foraging habitat of the arctic peregrine falcon, which was listed as endangered under the Endangered Species Act (ESA) in 1973 (BLM 2008a). Although the arctic peregrine falcon was delisted in 1994, the CRSA continues to be recognized as important nesting and foraging habitat, and purpose of the CRSA was expanded to provide maximum protection for all raptors while allowing other activities to occur, including oil and gas development, recreation, subsistence, and scientific research (BLM 2013).

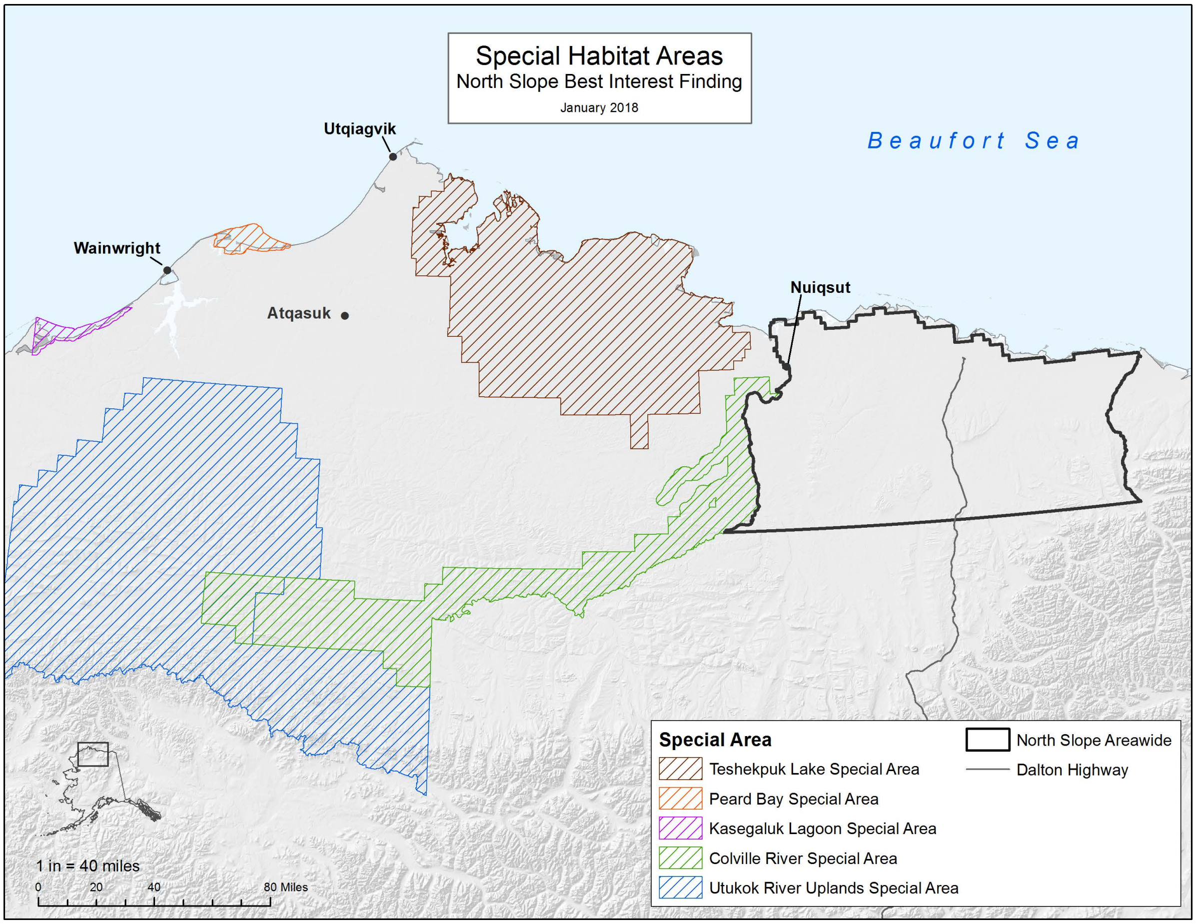

Figure 4.2.—Federally designated habitat areas.

C. Fish and Wildlife Populations

Alaska Game Management Units (GMUs) are geographical subdivisions established to effectively manage and control hunting and other wildlife uses in Alaska. As defined in 5 AAC 92.450, Alaska is divided into 26 GMUs, with certain units subdivided into smaller sections as needed. Regulations govern each unit establishing seasons and bag limits, and methods and means for the harvest of wildlife. The North Slope Borough stretches through all GMU 26, and into the northern portions of GMU 23, 24, and 25 (*See* figure 4.3). The Sale Area is wholly contained in GMU 26B. The following discussion of fish and wildlife populations focuses on species present within GMU 26B, but will also include areas adjacent to the Areawide boundary between Utqiaġvik and Kaktovik.

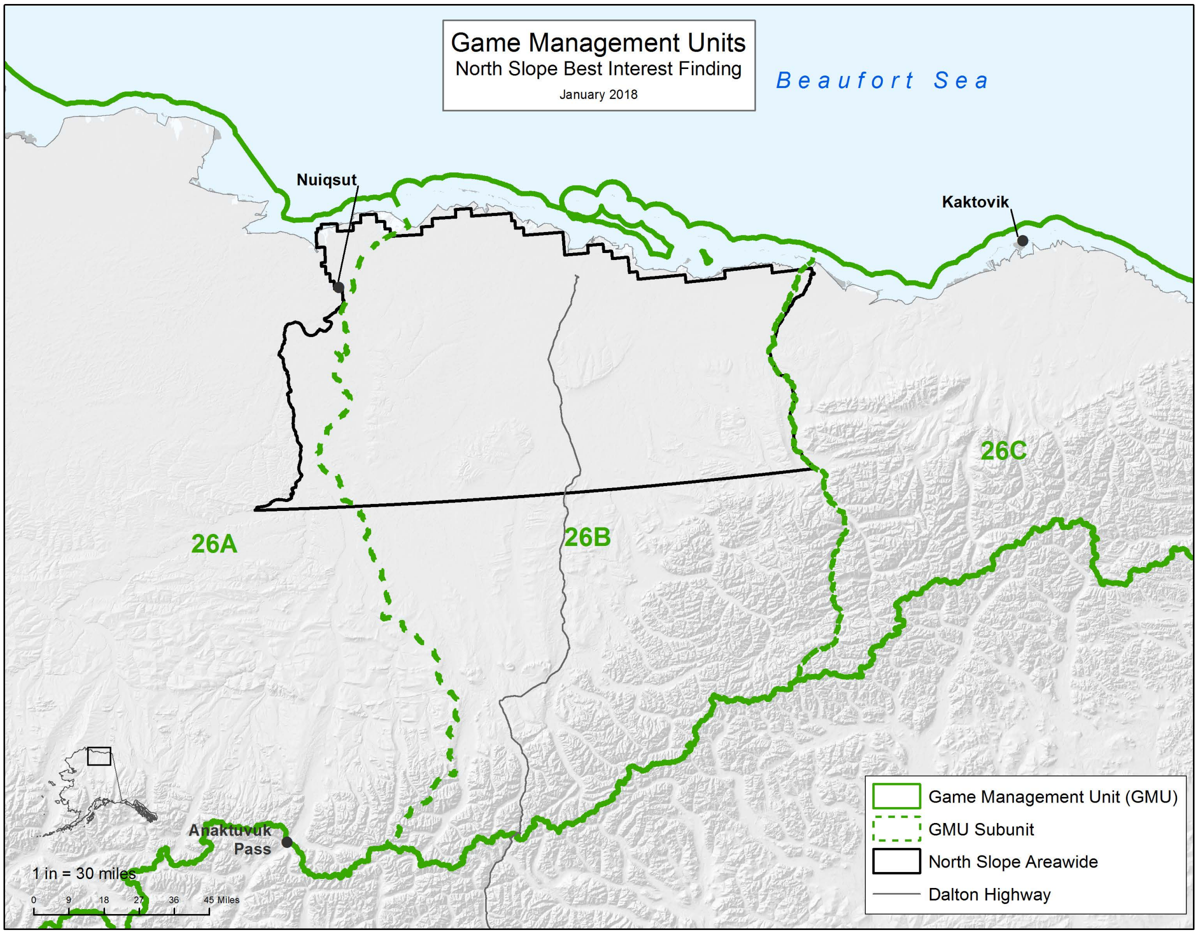

Figure 4.3.—North Slope game management units.

1. Fish

Fish species on the North Slope may be categorized into several groupings based on their lifecycle: anadromous, amphidromous, freshwater, and marine. Anadromous fishes hatch and may initially rear in freshwater systems before migrating to the sea where they spend most of their adult lives before returning to their natal streams to spawn and die. Key anadromous species found in the Sale Area include Arctic char, Dolly Varden, Arctic cisco, Bering cisco, chum and pink salmon, and rainbow smelt. Depending on the species, juvenile anadromous fish can spend up to four years maturing and feeding in freshwater before moving to marine waters (Brown 2008). Also depending on species, adults can spend up to five years feeding and growing to maturity in nearshore marine waters before returning to natal waters to spawn (Froese and Pauly 2016).

Amphidromous fishes cycle annually between freshwater and coastal marine environments. They spawn and overwinter in rivers and streams but migrate to coastal waters for several months each summer to feed. Amphidromy enables fish to take advantage of the more plentiful food resources present in Arctic coastal waters during summer. In comparison to anadromous fishes, amphidromous species live longer, grow more slowly, and become sexually mature later in life (Froese and Pauly 2016). Key amphidromous species found in the North Slope region include:

broad whitefish, humpback whitefish, and least cisco (Froese and Pauly 2016; Fechhelm et al. 2009; Brown 2008). Amphidromous fish can spawn either in a marine or freshwater environment, and do not necessarily die afterwards, as with anadromous fish. Most amphidromous spend more time in brackish, nearshore waters than in marine waters, but some populations of least cisco and humpback whitefish remain within freshwater river and lakes year-round (Fechhelm et al. 2009).

Freshwater species largely remain within freshwater river, stream, and lake systems year-round, although they may venture out during summer into coastal areas where waters are brackish (Froese and Pauly 2016). These fish feed, spawn, rear, and overwinter throughout these watersheds. The abundance of most arctic freshwater fish is limited by the availability of proper wintering habitat. Large drainage systems such as the Colville, Sagavanirktok, and Canning rivers support diverse populations of freshwater fish species. The key freshwater species in the area include Arctic grayling, round whitefish, lake trout, Alaska blackfish, ninespine stickleback, and slimy sculpin (Froese and Pauly 2016).

Marine fishes spend their entire lives at sea, although some species may migrate into nearshore coastal waters during summer to feed. Occasionally, marine and migratory fish species will be in direct competition with one another for food, usually in the nearshore areas. Key marine fishes in the North Slope region include Arctic cod, fourhorn sculpin, and arctic flounder (Logerwell et al. 2015; Froese and Pauly 2016).

Five species of Pacific salmon have been observed in the Arctic, but these are rare by comparison to the more abundant species such as whitefish and char (BOEM 2013 citing Fechhelm 2009). Pink and chum salmon are the only two Pacific salmon species that have been identified in scientific literature to maintain natal streams between northwest Alaska and the Mackenzie River (Irvine et al. 2009). For example, while whitefish and char are the dominant species in the Colville River, chum and pink salmon have also been found. Additionally, whitefish are regionally more abundant in the Sale Area and harvested in greater numbers than Pacific salmon (BOEM 2013; Fechhelm et al. 2009). Other species found in the Colville River include Dolly Varden, Arctic grayling, burbot, ninespine stickleback, and slimy sculpin (Moulton and Seavey 2005).

Dozens of lakes in the Sale Area contain lake trout, Arctic char, Arctic grayling, and burbot. Generally, these populations are slow growing (Scanlon 2015). Arctic cisco, broad whitefish, and Dolly Varden usually overwinter in large rivers that do not completely freeze, such as the Sagavanirktok (Fechhelm et al. 2009). However, Arctic grayling, Dolly Varden, and whitefish may also migrate and overwinter in deeper waters (ADF&G 2006).

a. Whitefishes

At least six whitefish species occur on the North Slope including Arctic cisco, least cisco, broad whitefish, humpback whitefish, round whitefish, and Bering cisco (Fechhelm et al. 2009; Moulton et al. 2010). Whitefish are among the most common group of fish in the region, and are one of the preferred fish eaten by the North Slope Iñupiat. Whitefish use essentially every habitat, summering in marine waters, and spending winter in either freshwater or brackish water within large river deltas (Fechhelm et al. 2009; Morris 2006).

Arctic cisco are considered anadromous because they overwinter in the lower reaches of major river systems in brackish water and do not move far upriver into strictly freshwater habitats. It is believed that most or all Arctic cisco found in the Beaufort Sea originate from the Mackenzie River in Canada. The Colville River is a major overwintering habitat for Arctic cisco although some juveniles may overwinter in the Sagavanirktok delta (Brown 2008; Streever and Bishop 2014). In the spring, newly hatched fish are flushed into Canadian coastal waters where many young-of-the-year are transported westward to Alaska toward the Colville River, aided by easterly winds during summer (July 1 to August 31). Fish typically remain associated with the Colville River until the onset of sexual maturity beginning at approximately age seven, at which point they migrate east, back to the Mackenzie River to spawn (Brown 2008; Streever and Bishop 2014). It is believed that newly hatched and juvenile Arctic cisco move westward toward the Colville River, aided by the easterly winds during summer; thus, these fish must pass through the area of coastal development associated with the Prudhoe Bay and Kuparuk oil fields. Arctic cisco of the Colville River delta spend most of the summer feeding in nearshore coastal waters, and then return to the river's channels and lakes in September and October to overwinter (Moulton et al. 2010). Adult Arctic cisco eat crustaceans and small fishes. However, juveniles' feeding habits are unknown (ABR Inc. et al. 2007). Arctic cisco are also a food source for larger fish and marine mammals (Fechhelm et al. 2009).

Least cisco on the North Slope exhibit two different life history patterns, amphidromous and freshwater forms. Some freshwater populations are migratory, moving among lakes, streams and rivers, while others are non-migratory or lake-dwelling populations. Growth, maturity, and size are usually dictated by habitat. Migratory populations are observed to live longer than freshwater forms (Froese and Pauly 2016). Freshwater populations may consist of dwarf forms commingled with normal size fish. Amphidromous least cisco in the Sale Area occur in tundra rivers that lie west and include the Colville River. Most adult and juvenile least cisco found in the coastal waters of Prudhoe Bay are from Colville River stocks. Least cisco feed on planktonic crustaceans and insects as well as plant material. Least cisco also play an important role in the food chain, as they are eaten by predacious inconnu, northern pike, and burbot (Brown 2008).

Broad whitefish are present throughout drainages of the North Slope. Broad whitefish are amphidromous, but most stay within a river system migrating between streams within the main drainage. Alaskan populations of broad whitefish are typically associated with tundra rivers that lie west of and including the Sagavanirktok River (Brown 2008; Fechhelm et al. 2009). Fish collected in the Prudhoe Bay area can often be traced to either the Colville or Sagavanirktok River stocks (Fechhelm et al. 2009; Olsen et al. 2007). Portions of the Colville River may be a significant spawning or wintering area for North Slope broad whitefish between the Sagavanirktok River to the east and the Kalikpik River to the west (Fechhelm et al. 2009). Most broad whitefish mature between 8 and 10 years old, and it is common to find specimens aged 20 years or more. Broad whitefish spawn from fall to early winter, and not all fish spawn every year. Broad whitefish are the principal species targeted in the Colville River summer subsistence fishery (Fechhelm et al. 2009 citing Moulton et al. 1986 and Nelson et al. 1987).

Humpback whitefish appear similar to broad whitefish and they are sometimes confused with one another. Humpback whitefish have a discontinuous distribution across the North Slope, and can be found in North Slope lakes, streams, and rivers west of the Sagavanirktok River. Humpback whitefish are considered truly anadromous, and have been found in the Beaufort Sea several miles offshore of the Colville and Sagavanirktok rivers; however, some populations may be freshwater residents. Humpback whitefish begin migrating to freshwater for spawning in June, and spawning take place in October. They may spawn under the ice in some locations. They become sexually mature between four and six years old. Eggs likely hatch in late winter and spring, and then the young are assumed to move down river (Brown 2008).

Round whitefish are found in many freshwaters of the Beaufort Sea area (Morrow 1980). On the North Slope, they have been documented in the upper reaches of large river systems such as the Colville, Sagavanirktok, and Miluveach rivers. They are also common in the Colville River delta (Brown 2008; Morrow 1980). They make upstream migrations to spawn, and probably spawn annually in late September through October. Round whitefish reach sexual maturity between age five and seven years old, depending on the location, and they may live as long as 16 years (ADF&G 1994c).

Bering Cisco are similar to Arctic cisco in appearance and life history. Juveniles migrate out to sea from freshwater during their first summer. They feed and overwinter primarily in coastal and estuarine areas, rarely venturing into freshwater habitats, until they reach maturity at about five to eight years of age (ADF&G 2006; Fechhelm et al. 2009). While more common in the western areas of the North Slope, Bering cisco have been documented in nearshore Beaufort Sea at least as far east as the Prudhoe Bay region (ADF&G 2006). Bering cisco have been captured in the Kuk and Ivisaruk rivers, the Teshekpuk Lake region, and in the Avalik River. Bering cisco are an important forage fish for various freshwater and marine predators (ADF&G 2015).

b. Char

The Sagavanirktok River is a major producer of Dolly Varden (Brown 2008 citing Yoshihara 1973 and Viavant 2005). Capable of spawning multiple times during their lives, Dolly Varden are known to spawn in the Sagavanirktok and Colville rivers. Smolts, aged two to three, have been captured in Prudhoe Bay after emerging from the Sagavanirktok River (Brown 2008 citing Fechhelm et al. 1997). Anadromous Dolly Varden from Beaufort Sea drainages spawn during the fall or early winter in freshwater, then remain in freshwater through the winter. Older tagging studies and recent genetics work suggest mature Dolly Varden in northern Alaska overwinter mainly in their natal streams, whether they are spawning or not, which is contrary to 1974 and 1985 studies (Brown 2008 citing Furniss 1975; Crane et al. 2005). Dolly Varden are more of a scavenger than a predator. In freshwater, they may eat winged insects and larvae. They also may eat drifting salmon eggs, small crustaceans, and small fish. In the ocean, they may feed on amphipods and small fish (Stewart et al. 2009).

Arctic char occur in the lakes of the north-facing drainages of the Brooks Range. Often confused with Dolly Varden, a closely related species that inhabit the same locations as Arctic char, definitively distinguishing between the two requires close examination of several body structures. Arctic char have light colored spots on a dark background. They are variable in color depending on environmental conditions within their lake of residence and time of year. Additionally, Arctic char generally have a shorter head and snout (a trait particularly evident in spawning males), a more deeply-forked tail, and a narrower caudal peduncle (the area before the tail fin). Spawning takes place in lakes between the fall months of August and October. Most char are ready to spawn between age six and nine years old, and individuals usually spawn only every other year. Spawning sites are chosen based on water depth, as thick ice can freeze to the bottom in shallower portions of lakes. Arctic char spend their entire lives in lakes and do not migrate. They feed on a variety of different food items from zooplankton and insects to other fish, including smaller char, depending upon the specific water body, their age and relative size, as well as time of year (ADF&G 1994a).

c. Salmon

Although five species of Pacific Salmon have been recorded in the coastal waters of the North Slope in the summer, Chinook, sockeye, and coho salmon are extremely rare, and no known spawning stocks have been identified in the region (Fechhelm et al. 2009 citing Craig and Haldorson 1986, Fechhelm and Griffiths 2001, and Stephenson 2006). The northernmost population of spawning coho salmon is near Point Hope, Alaska, over 400 miles west of the Sale Area. Coho salmon have occasionally been captured in marine waters farther east near Prudhoe Bay (Stephenson 2006 citing Craig and Halderson 1986).

One study noted that after 27 years of annual fish sampling in the Prudhoe Bay area, a total of 716 salmon had been caught: 664 pink, 51 chum, and 1 Chinook (Fechhelm et al. 2009). Pink and chum salmon are more cold tolerant than the other salmon species, and complete the majority of their life cycles in marine waters (Irvine et al. 2009). Immediately after hatching, both species swim into estuarine or marine environments and complete their life cycles outside of freshwater. It is believed, but not confirmed, that pink and chum salmon are natal in many of the streams and rivers in the Prudhoe Bay area (Irvine et al. 2009).

Small runs of pink salmon occur in the Colville River, and anecdotal evidence indicates that that the amount of pink salmon taken near the Itkillik River is increasing (Fechhelm et al. 2009). Pink salmon are the smallest of the five species of Pacific salmon, weighing between three and five pounds. Pink salmon females lay between 1,200 and 1,900 eggs. They generally spawn in the lower reaches of streams within a few miles of the ocean, and may even spawn in intertidal areas. Most pink salmon do not travel more than 40 miles up a river to spawn. Because pink salmon migrate to the ocean shortly after emerging from gravel and spend only one year in the ocean, they have a distinct two-year life cycle from egg to spawning; therefore, populations are characterized as either odd- or even-year (Peter and Haldorson 1986). During their migration to the ocean, pink salmon generally do not eat as they leave freshwater. For the few that spawn further inland, they may feed on aquatic insects. Once in the ocean, pink salmon feed on plankton, small fish, squid, and tiny marine crustaceans (ADF&G 1994b).

Small runs of chum salmon occur in the Colville River drainage (BOEM 2013). Chum salmon on the North Slope tend to be smaller, ranging from 6 to 10 pounds and 20 to 27 inches in length (Peter and Haldorson 1986). Chum salmon females lay between 2,000 and 4,000 eggs. After hatching in the spring, young chum immediately migrate into the ocean. They form large schools and remain in estuaries and near-shore waters feeding on plankton until fall, when they migrate to the open ocean. While in the ocean, chum salmon feed on copepods, tunicates, mollusks, and a variety of fishes (Irvine et al. 2009). After three to six years at sea, chum return to their home streams to spawn. Pacific salmon die after spawning, but their decomposed bodies provide essential nutrients that contribute to the productivity of the entire stream ecosystem (Walker and Davis 2004).

d. Other Fish Species

Arctic cod are one of the most abundant species found in waters of the Beaufort Sea (Wiswar and Fruge 2006). They are generally found in brackish lagoons, river mouths, and in nearshore marine waters, although they sometimes occur in deeper waters and farther offshore (Mecklenburg et al. 2002). They are one of the dominant species found in Simpson Lagoon and adjacent coastal waters of the Beaufort Sea during both summer and winter (Logerwell et al. 2015). Arctic cod are tolerant of cold water and often live along the edges of pack ice inhabiting narrow wedges of seawater along the melting edges of ice floes (Gradinger and Bluhm 2004). Arctic cod are a critical component of arctic food webs as they are one of the main species that transfers planktonic organisms to other fish, birds, and wildlife (Welch et al. 1992; Welch et al. 1993). They are important food prey for other fish, seals, beluga whales, narwhals, and seabirds (Harwood et al. 2015).

Arctic grayling are one of the most abundant and widespread freshwater species in the Colville River drainage above the confluence of the east and west delta channels, and can be migratory, or may remain in the same section of a stream (BOEM 2013). In addition to the Colville River, Arctic grayling typically overwinter in deep areas within large river systems such as the Kuparuk, Sagavanirktok, and Canning rivers. They are distributed throughout all the major river drainages, including many small tributaries and lakes, ranging from the coast to the upper-most reaches of mountain headwaters. They tend to seek the deep reaches on lower clear rivers, and tolerate low oxygen regimes over long winter seasons (Scanlon 2015; Reynolds 1997). In spring, adults move to tributaries to spawn, and then move further downstream into lakes or the main channel to feed in the summer (National Research Council 2003).

Arctic flounder and fourhorn sculpin are also found near the Sale Area, and may be abundant in Prudhoe Bay (BOEM 2013). Arctic flounder live permanently near the coast and spawn beneath the ice from January to March (Logerwell et al. 2015). Fourhorn sculpin are abundant in Beaufort Sea coastal waters. Their home range includes deep waters not frequented by anadromous or amphidromous species (Fechhelm et al. 2009).

2. Birds

Major concentrations of birds occur in and near portions of the Sale Area. Important nesting and breeding area for waterfowl include the deltas of the Colville, Sagavanirktok, Kuparuk, and Canning rivers, Fish Creek, and Simpson Lagoon (Johnson et al. 2013). A variety of bird species are found among the several habitat types of the Sale Area.

The deltas of the Colville, Sagavanirktok, and Kuparuk Rivers provide important breeding and brood-rearing habitats for tundra swans, black brant, snow geese, and Canada geese (Stickney et al. 2013). Located in the Sagavanirktok River delta, Howe Island, is home to one of the few known snow goose nesting colonies in the United States (CPAI 2005a). The Return Islands, Jones Islands, McLure Islands, Cross Island, and Lion Point are important for nesting common eider. Thousands of long-tailed ducks concentrate near Flaxman Island to molt. Greater white-fronted geese are also found nesting and rearing in the major deltas and other coastal plain areas (Bart et al. 2012).

The most abundant marine and coastal species include red phalarope, northern pintail, long-tailed duck, glaucous gull, and king and common eider. Nearly all of these species are migratory and are found in the Arctic seasonally, generally from May through September. Shortly after spring migration, most shorebird and waterfowl populations disperse to nesting grounds, primarily on tundra and marshlands of the Arctic Slope. Beginning in late June, large concentration of long-tailed ducks and eider occur in coastal waters inshore of islands where the birds feed and molt before fall migration (Bart et al. 2012). Use of lagoons and other coastal habitats peaks in August to late September before and during the fall migration. Among the least abundant species in the Sale Area are the Steller's eider and the spectacled eider (Stehn et al. 2013). As of March 2017, both are listed as threatened under the ESA (USFWS 2016b, c).

a. Waterfowl

Habitats of the Sale Area support numerous waterfowl, some of which inhabit the area seasonally, and some year-round. Species found nesting on the coastal plain include greater white-fronted geese, snow geese, tundra swans, brant, yellow-billed loons, and common, king, Steller's and spectacled eiders (ADF&G 2006; Bart et al. 2012).

Tundra swans are common along the Arctic coast of Alaska, and are one of the first birds to arrive in the spring on the BCP, usually in mid-May. Considered to be an indicator of the overall health of waterbird populations and their wetland ecosystems, tundra swans are an important component of the waterbird community in northern Alaska (Stickney et al. 2013). Common breeders, they begin nesting during the last week of May and the first two weeks of June. After hatching in late June or early July, broods are reared in nesting territory. Adults molt from mid-July through August. Substantial numbers of tundra swans stage in late summer just west of Teshekpuk Lake. Interim habitat is provided in the headwaters of the Anaktuvuk, Colville, Killik, Nigu, Etivluk, Nuka, Utukok, and Kokolik rivers in years when persistent ice delays movement onto nesting grounds (Johnson et al. 2013). Fall migration occurs from late September to early October (CPAI 2005b).

Population data collected from 1986 to 2012 shows an annual population growth rate (total bird index) of 1.046, indicating a positive population growth trend for tundra swans across the BCP (Stehn et al. 2013). Similarly, the 2011 population estimate of 9,792 shows a positive growth in long-term from 1986 to 2011, and in the 10-year period from 2001 to 2011 (Larned et al. 2012). Data collected in the Kuparuk oilfield and Colville River delta between 1989 and 2012 shows a significant increase of the number of swan nests and swan density observed in 2012 versus the long term means: 101 versus 88.3 and 715 versus 449.8 respectively (Johnson et al. 2013; Stickney et al. 2013).

Greater white-fronted geese are common breeders along the Beaufort Sea coast. They reach Beaufort Sea breeding areas from the second week of May to the first week of June. Fall migration begins in early to mid-August and most are gone by the end of September (Johnson et al. 2013). The 2011 population index was 157,481 which exceeded the 20-year mean of 95,546 by 65 percent. The population data shows an increase in growth rate over the long term of 1.057 between 1992 and 2011, as well as during the 10-years between 2002 and 2011 when the growth rate was calculated at 1.113. The breeding population in the BCP experienced a sudden large jump after 2006, but researchers have been unable to explain what caused the large increase after the population data between 1992 and 2005 showed a gently increasing trend (Larned et al. 2012).

Spectacled eiders migrate and arrive on their breeding grounds on the BCP by late May or June. Breeding females and their young are found on the nesting grounds until late August or early September, although females whose nests have failed return to sea by late July. Males only remain on shore for a few weeks, returning to sea after eggs have been laid by the end of June. Females move to molting areas in July if unsuccessful at nesting, or in August to September if successful. By late summer, the females and young travel to their wintering grounds along established migration corridors in the Bering, Chukchi, and Beaufort seas. The distribution of non-breeding spectacled eiders from May to October is poorly documented. The spectacled eider was listed as a threatened species under the ESA in 1993 (58 FR 27474), largely based on steep declines in the Yukon-Kuskokwim Delta and BCP breeding populations (USFWS 2010). Critical habitat was designated in 2001, and refers to the specific areas within the geographic area occupied by the species at the time it was listed that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection (66 FR 9146). Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation. In 2011, the spectacled eider index was 7,952, which was higher than the 19-year mean of 6,580 between 1991and 2010. Data shows the index growth rate has remained stable over the long-term period between 1993 and 2011 at 0.992, as well as in the short term 10-year period between 2001and 2011 at 0.997 (Larned et al. 2012).

King eiders have a circumpolar distribution, but are particularly abundant along the eastern Beaufort Sea coast. King eiders winter in the Bering Sea and north Pacific Ocean, including Kodiak, along the Alaska Peninsula and the Aleutian Chain (Johnson et al. 2013). In the spring, they migrate north to Russia, Alaska, and northwestern Canada. Those nesting in Alaska and Canada migrate past Point Barrow and across the Beaufort Sea during the spring migration. King eiders may begin moving into the Beaufort Sea area as early as mid to late April, with large numbers arriving by mid-May. King eiders migrate in the fall from northwestern North America to several known molting and wintering areas across Alaska. Migration routes and timing are determined largely by offshore lead systems in the Beaufort Sea pack ice. As of 2008, detailed information about the timing, extent, and variability of migratory routes was lacking (Oppel et al. 2008). In 2011, the king eider population was estimated to be approximately 18,942, which was 33 percent higher than the 19-year mean of 14,236 between 1992 and 2011, and was the second-highest index since 1992. Data shows the index growth rate has increased over the long term period from 1992 to 2011 at 1.027, as well as in the short term 10-year period between 2002 and 2011 at 1.040 (Larned et al. 2012).

Steller’s eider, the smallest of the eiders, have a breeding range reaching from Russia to Alaska’s Arctic coastal plain, primarily near Utqiaġvik. Only one percent of Steller’s eider nest in the North America and wintering range is found entirely in Western Alaska. Populations have declined from (ADF&G 2018c). The sharp decline in Steller’s eider populations influenced a listing of the Alaska-breeding Steller’s eider as threatened in 1997 under the ESA. Critical habitat was designated in southwest Alaska in areas from the Yukon-Kuskokwim delta to the Izembek Lagoon. No part of the Sale Area was designated as critical habitat (ADF&G 2018b).

Yellow-billed loons are the least abundant loon species on the BCP; however, the Colville River delta supports some of the highest densities of breeding yellow-billed loons in Alaska. Yellow-billed loons are large-bodied, fairly long-lived birds with a low annual reproductive output, and therefore, are dependent upon high annual adult survival to maintain populations (Stehn et al. 2013; Federal Register 2014). Yellow-billed loons nest exclusively in coastal and inland low-lying tundra, in association with permanent fish bearing lakes. Breeding is thought to be limited primarily by availability of breeding habitat, specifically, nesting and brood-rearing lakes (USFWS 2006).

Yellow-billed loons arrive in the Sale Area in late May. They concentrate during spring with other species of loons in early-melting areas off the deltas of the Sagavanirktok, Kuparuk, and Colville rivers. Yellow-billed loons migrate between summer breeding grounds in the Arctic tundra and coastal wintering grounds to the south and east. The peak fall migration happens from late August to mid-September (Stehn et al. 2013). Data from surveys conducted from 1986 to 2012 showed an increasing trend with a total bird average growth rate of 1.014 for all years, and an average growth rate of 1.050 from 2003 to 2012 (Stehn et al. 2013). While actual population size is unknown, population estimates calculated from data obtained from intensive lake-circling surveys compared to transect surveys are in line with trend data, reporting a 36-year average population of 1,934 for the years 1986 to 2012, and a 10-year average population of 2,531 for years 2003 to 2012 (Stehn et al. 2013). In 2014, after conducting a status assessment for the yellow-billed loon, USFWS determined listing the species as endangered or threatened under the ESA was not warranted at that time (Federal Register 2014).

Of the 34 species surveyed during annual monitoring of waterfowl populations on the BCP between 1986 and 2012, snow geese showed the most rapid growth rate. If the observed growth rate noted from 2002 to 2012 continues, the snow goose population will double every 3.3 years, increasing eight-fold in 10 years (Johnson et al. 2013). White-fronted geese and black brant showed stable or increasing populations. The population trends for snow geese and black brant from the BCP survey are supported by more intensive monitoring studies that have been conducted from Utqiaġvik to the Colville Delta (Stehn et al. 2013 citing Burgess et al. 2011).

Another study conducted in the Colville Delta area in 2012 included aerial surveys of snow geese, tundra swans, spectacled and king eiders, and yellow-billed loons. These species were selected for the survey because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, 4) importance to subsistence hunting, and 5) concern by regulatory agencies for development impacts. Results of this study indicated an above average abundance of snow geese, tundra swans, and yellow-billed loons while abundance of spectacled and king eiders and brant was about average (Johnson et al. 2013; Stickney et al. 2012). Similarly, productivity of snow geese was notably high (Johnson et al. 2013).

Northern pintail is one of the most abundant duck species in the Northern section of the BCP. Northern pintails, long-tailed ducks, and White-fronted geese make up about 81 percent of the common waterbird population on the BCP (Bart et al. 2012; Stehn et al. 2013).

b. Seabirds and Shorebirds

Alaska's productive sea and isolated islands provide habitat for one of the largest and most diverse assemblages of seabirds in the world. Ten species of seabirds are known to occur within or adjacent to the Sale Area: glaucous, Sabine's and Ross's gulls, pomarine, parasitic and long-tailed jaegers, Arctic tern, black guillemot, horned puffin, and Kittlitz's murrelet (BLM 2014). Marine birds are indicators of the health of the marine ecosystem. Various species of seabirds use different portions of the marine food web. Most seabirds arrive on the BCP in early to late May and leave between September and November.

Glaucous gulls are common migrants and breeders in the Sale Area. Glaucous gulls select several types of nesting sites, depending on availability. Pairs nest either on low islands and sandbars near or on the coast, or on inland river bars or small islands in lakes (Weiser and Powell 2010). Glaucous gulls are common from March through November in the Sale Area, arriving at their breeding sites in late winter and early spring. During fall migration, glaucous gulls move away from the Sale Area beginning in October. During winter the gulls are found near the Kamchatka Peninsula and in the Sea of Okhotsk. The vast majority of spring migration takes place in May with much of the movement taking place overland rather than along the coast. Breeding birds have very small core use areas, but large home ranges, indicating that birds remain very close to their nests for the majority of the nesting and chick-rearing periods (Petersen et al. 2015).

Aerial bird surveys of the BCP have documented glaucous gull populations since 1992, with a mean population index of approximately 13,000 that was considered stable from 1992 to 2006, but increased from 2001 to 2010 (Petersen et al. 2015). In 2012, the total bird population index for glaucous gulls was 17,616 (Stehn et al. 2013). Aerial surveys conducted that same year in the Colville Delta indicated the glaucous gull population was above average with notably high productivity (Johnson et al. 2013). While it is not clear what caused the shift, researchers suggest that glaucous gull abundance is positively correlated with the availability of human food waste. A 2010 study of glaucous gull diet on the BCP using both pellet and isotope analysis determined that gulls breeding near Deadhorse obtained a large portion of their diet from anthropogenic sources while gulls from the other sites such as the Alpine Satellite Development area located in the Colville River delta and Utqiaġvik were using largely natural food sources (Weiser and Powell 2010). Although the gulls nesting near Deadhorse obtained considerable anthropogenic food, the telemetry data suggest that the Prudhoe Bay landfill was not the source. The breeding birds that were outfitted with transmitters in Deadhorse did not visit the landfill, but did include much of Deadhorse in their home ranges indicating scavenging in the town (parking lots, beds of pickups, dumpsters) (Weiser and Powell 2010 citing Troy 2007, 2010).

The BCP is also important habitat to shorebirds, both nationally and internationally. The bulk of the U.S. breeding population of long-billed dowitcher; dunlin; and semipalmated, pectoral, buff-breasted, and stilt sandpipers occurs here (ADF&G 2006). More than two dozen shorebird species breed on the BCP, with over 6 million birds estimated to breed adjacent to the Sale Area on the NPR-A with the most abundant species being American golden-plover, semipalmated sandpiper, pectoral sandpiper, dunlin, long-billed dowitcher, red-necked phalarope, and red phalarope (Bart et al. 2012; ADF&G 2006). Many shorebird species use the coastal areas for staging prior to migrating to southern parts of the Western Hemisphere, Southeast Asia, Oceania, Australia, and New Zealand (ADF&G 2006).

Habitat selection for shorebirds varies depending on species and life stage. In general, habitats used by shorebirds for breeding, nesting, and brood-rearing differ from those used for pre-migratory staging. Many shorebirds nest and rear broods in tundra habitats, then migrate to coastal littoral zone habitats for pre-migratory staging (Powell et al. 2010). A 2013 analysis of bird surveys and habitat information showed the suitability of breeding habitat for most shorebirds on the BCP increased at lower elevations, suggesting that many shorebirds may favor wet or moist lowland habitats. Most breeding shorebirds on the BCP are observed more frequently near the coast than in the foothills of the Brooks Range, and the low elevation wetland habitats generally preferred by several shorebirds are often located near the coast (Saalfeld et al. 2013).

After breeding, but before their southern migration, many shorebirds stage on coastal littoral habitats where they forage and develop fat stores. Species such as black-bellied plovers, red phalaropes, rednecked phalaropes, ruddy turnstones, and sanderlings tend to prefer gravel beach habitats, while dunlin and semipalmated sandpipers tend to prefer mudflats. Long-billed dowitchers, pectoral, and western sandpipers show a strong selection for pond edge, which is often interspersed with salt marsh at North Slope coastal areas (Powell et al. 2010). Habitat preferences are likely influenced by prey availability, feeding mechanics, and foraging strategies (Liebezeit et al. 2014).

Shorebird nesting densities on the BCP vary depending on location and habitat. Results from a study that considered all habitat types on the BCP reported a greater overall shorebird nest density of approximately 234 nests per square mile in the Colville River delta near the Alpine Satellite Development area, where nests were associated with the habitat types of wet sedge willow and moist sedge shrub (Liebezeit et al. 2009). One of the most important areas for shorebirds adjacent to the Sale Area in the NPR-A may be the area north of Teshekpuk Lake where shorebird densities as high as 355 pairs per square mile were reported in areas northeast and northwest of the lake (Liebezeit et al. 2011 citing Andres 2004). A study conducted in the Olak region of the Teshekpuk Lake Special Area from 2006 to 2008 found 12 species of shorebirds in the study area with pectoral and semipalmated sandpipers and red phalaropes accounting for the greatest numbers of nests found. Additionally, overall nest density (all nests of all species including non-shorebird species) was 342 nests per square-mile in 2006, 259 nests per square mile in 2007, and 256 nests per square-mile in 2008 (Liebezeit and Zack 2007; Liebezeit et al. 2011). Nest predation was found to be the most important cause of nest failure (Liebezeit et al. 2009).

An analysis of species composition and abundance indicated nesting individuals of seven shorebird species were present on significantly more plots in the western part of the BCP from Icy Cape to the Colville River, much of which is adjacent to the Sale Area, than in the eastern portion of the BCP from the Colville River to Aichilik River. These species included the bar-tailed godwit, semipalmated sandpiper, pectoral sandpiper, dunlin, long-billed dowitcher, red phalarope, and western sandpiper. Only one species, the American golden-plover, was more prevalent in the eastern than the western portion of the BCP (Brown et al. 2007). Similarly, survey plots supported a significantly higher average number of species in the west than in the east. The highest species richness occurred at Admiralty Bay, the Alaktak River, the Ikpikpuk River and delta, the area surrounding Teshekpuk Lake, and the Fish Creek delta (Powell et al. 2010 citing Johnson et al. 2007).

A bird monitoring study conducted between 1998 and 2001 surveyed 386 variable-sized plots adjacent to the Sale Area distributed throughout the NPR-A, covering approximately 43 square miles. Biologists counted 4,445 shorebirds belonging to 17 species during the four survey years. The highest counts of shorebirds occurred in the northern portion of NPR-A, followed by areas near the Colville River, and then the southern portion of NPR-A. The most numerous species detected were semipalmated sandpiper (1153), pectoral sandpiper (943), red phalarope (669), red-necked phalarope (435), long-billed dowitcher (353), and dunlin (343). Other less common species included black-bellied plover, American golden-plover, whimbrel, bar-tailed Godwit, ruddy turnstone, western sandpiper, white-rumped sandpiper, Baird's sandpiper, buff-breasted sandpiper, stilt sandpiper, and Wilson's snipe (Bart et al. 2012 citing Bart and Earnst 2005). Four of the species, dunlin, whimbrel, bar-tailed Godwit, and buff-breasted sandpiper are on the U.S. Fish and Wildlife Service's Birds of Conservation Concern list for the Arctic Plains and Mountains Bird Conservation Region (USFWS 2008).

c. Raptors

Raptors are considered an indicator species of ecological changes and human-induced influences or impact because they are high trophic-level (top of the food chain) predatory birds. Arctic peregrine falcons nest south of the Sale Area primarily on bluffs along the Colville River from Umiat to Ocean Point, and at Franklin and Sagwon Bluffs in the Sagavanirktok River drainage (BLM 2008a). Additional nest sites may occur at other locations. Arctic peregrine falcons are present on the North Slope from late April through September. Nesting begins by mid-May, and the young birds fledge from late July to late August. Immature peregrine falcons from the Colville to the Sagavanirktok River drainages move toward the Beaufort Sea coast in mid to late August. Peregrine falcons generally leave the North Slope by late September (BLM 2008b).

The gyrfalcon is the largest falcon species and the most northern diurnal raptor. It is migratory with a circumpolar distribution, including summer breeding sites in Alaska. Gyrfalcons are most common on the North Slope east of the Sagavanirktok River and west of the Anaktuvuk River, with relatively low numbers along the Sagavanirktok River. The Colville River and adjacent drainages support a substantial proportion of the North Slope population (Trammell et al. 2015 citing Johnson and Herter 1989). Gyrfalcons are also common east of the Canning River in the ANWR. Individuals are typically present on their breeding grounds from March to September; however, there is evidence for winter occupation of nest sites in Alaska and other northern regions (Booms et al. 2010). Current population on the North Slope is estimated at 250 breeding pairs (Trammell et al. 2015 citing USFWS 2001). This species nests primarily on precipitous cliff faces and typically uses nests built by other species, particularly common raven, golden eagle, and rough-legged hawk. They lay one clutch, averaging 3.7 eggs per year, which is incubated for approximately 35 days. Pairs may not breed every year, depending on prey availability (Booms et al. 2011). Ptarmigan are the preferred prey species, but they will also take birds ranging in size from passerines to geese. Foraging range during breeding is approximately 8-to-10 miles from the nest site (Nielsen 1999).

The peregrine falcon ranges throughout much of the world as either a seasonal migrant or resident. Peregrine falcons that breed in Arctic Alaska spend winters in Central and South America (Liebezeit et al. 2012). The principle nesting area in the North Slope study area occurs along the Colville River drainage including major tributaries such as the Etivluk, Oolamnagavik, Killik, and Chandler rivers, as well as the Sagavanirktok River (ADF&G 2006). Individuals are typically present on their breeding grounds from mid-April or mid-May to mid- or late-August. They lay one clutch averaging three eggs per year, which is incubated for 33 to 35 days (Wright and Bente 1999; Cade et al. 1968). Peregrine falcons prey primarily on bird species including passerines, shorebirds, and ducks. Foraging range during breeding is approximately five miles (Wright and Bente 1999).

The diversity of food habits varies annually for raptor species. Annual fluctuations in the population sizes of gyrfalcon and rough-legged hawk in Arctic Alaska are linked to the abundance of primary prey species, ptarmigan and lemmings, respectively, which are residents of the arctic environment. Similar population cycles have been documented between willow ptarmigan and gyrfalcon, although the regularity of willow ptarmigan cycles may be uncertain (Nielsen 1999). Peregrine falcon populations appear to be more stable from year to year, likely because peregrines primarily consume migratory bird species, whose populations are less affected by local conditions, and therefore less volatile than populations of resident species (Franke et al. 2011).

The Colville River bluffs and other rivers in the Arctic foothills are recognized as containing important nesting and foraging habitat, and are included as part of the CSRA. Originally created to protect the then endangered Arctic peregrine falcon, the purpose of this federally managed area has expanded to provide protection for all raptors including the gyrfalcon and rough-legged hawk (BLM 2008a). The gyrfalcon and occasionally the snowy owl overwinter in the area, while others migrate south to overwinter (ADF&G 2006).

d. Landbirds

Alaska is home to 135 species of breeding birds that principally use terrestrial habitats throughout the year. These birds, commonly referred to as “landbirds,” compose the largest and most ecologically diverse component of Alaska’s avifauna. Collectively, landbirds occupy all terrestrial habitats in Alaska, where they play vital roles in ecosystems by feeding on insect pests, pollinating plants, dispersing seeds, serving as prey, and acting as top predators. Declines in populations of landbirds, particularly resident species, could reflect the deterioration of ecosystem processes. Landbirds found in and adjacent to the Sale Area include Lapland longspur, Smith’s longspur, willow ptarmigan, rock ptarmigan, Savannah sparrow, redpoll, snow bunting, yellow wagtail, and numerous other species (ADF&G 2006; Martin et al. 2009). Smith's longspur is on the U.S. Fish and Wildlife Service's Birds of Conservation Concern list for the Arctic Plains and Mountains Bird Conservation Region, primarily due to threats on the winter and summer ranges (McFarland et al. 2017; USFWS 2008).

Most landbirds found on the North Slope winter at great distances from their breeding area, often in temperate or tropical regions in the Americas or southern Asia. Migratory landbirds generally arrive on the North Slope from late May to early June and remain until mid- to late- August (Liebezeit et al. 2011; Tulp and Schekkerman 2008). Lapland longspurs arrive in early June and are the first to nest, preferring moist habitats and wet meadows (Johnson et al. 2013). Willow ptarmigan begin moving around more outside their nesting area in September. In October and November, willow ptarmigan summering on the North Slope migrate further to good wintering grounds than ptarmigan inhabiting other parts of the state. Females may migrate as far as 100 miles away, wintering on the south side of the Brooks Range. Males will also migrate south, but not as far as females (Bart et al. 2012).

An analysis of ground and aerial survey data collected between 1995 and 2005 showed a total of 59 species from 17 families present across the entire BCP, with 34 of 59 species present in the upper Colville River alone. Lapland longspur are the most common species nesting in and around the Sale Area. Data collected between 1992 and 2005 estimated Lapland longspur density to be at least 104 birds per square mile east of the Sale Area (Bart et al. 2012). Similarly, data collected in

2006, 2007, and 2008 southeast of Teshekpuk Lake was consistent with other studies, with Lapland longspurs having the highest density among nesting passerine species with 110, 103, and 110 nests per square mile respectively (Liebezeit et al. 2011). Total population is estimated to range from one million birds in the Sale Area to as high as five million birds across the entire BCP (Bart et al. 2012).

Rock ptarmigan and willow ptarmigan are common breeders throughout the Sale Area. Willow ptarmigan are one of the most abundant species in the Sale Area. Both birds were found in all habitats, but willow ptarmigan demonstrate a preference for wetland or moist areas. Population estimates based on ground surveys conducted between 1992 and 2005 estimate there to be approximately 100,000–150,000 rock ptarmigan and approximately 900,000 willow ptarmigan in and around the Sale Area (Bart et al. 2012). Other species identified as common to abundant breeders in and adjacent to the Sale Area include American tree sparrow, Arctic warbler, bluethroat, snow bunting, and yellow wagtail (Martin et al. 2009). Snow buntings are very common in areas of development where they find nesting sites in crevices of buildings, pipelines, and other man-made structures (Liebezeit et al. 2009; McFarland et al. 2017).

3. Mammals

a. Terrestrial Mammals

The Sale Area is inhabited by several species of large terrestrial mammals, including caribou, moose, brown bear, muskox and wolves. Smaller mammals are usually listed together as furbearers. Furbearers found in the Sale Area include red fox, arctic fox, marten, mink, weasel, muskrat, wolverine, and least weasels.

i. Caribou

The North Slope is home to four of Alaska’s 31 caribou herds: the Western Arctic, Porcupine, Central Arctic, and the Teshekpuk caribou herds. These herds are differentiated by their use of geographically distinct calving grounds as opposed to being grouped by genetic differentiations. Historically, herds were more apt to mix during migration, but would usually return to calve with their native herd. However, as ranges expand and overlap, mixing during calving period and migration period is being observed at a greater rate. Additionally, researchers have noted an increase in emigration of adults and calves between herds, potentially blurring the distinctions, and population estimates, between the North Slope caribou herds (Harper and McCarthy 2015; Mager et al. 2013). While recent studies suggest that there is little genetic differentiation between the four herds that reside on the North Slope as a whole, subtle genetic patterns have been identified between the Western Arctic herd and the Porcupine herd, the most geographically distant herds (Mager et al. 2013).

As a herd animal, caribou must keep moving to find adequate food sources, and the seasonal ranges they choose have life history consequences that are strongly influenced by their nutritional environment (Harper and McCarthy 2015; Person et al. 2007 citing Griffith et al., 2002 and Cameron et al. 2005). Caribou maximize their nutritional intake through large-scale migratory movements to areas of higher habitat quality, changes in seasonal and annual distribution in response to changes in plant phenology and availability, and rapid movements to limit insect harassment (Person et al. 2007). For caribou, some plant species may provide greater nutritional value for migrating, gestating, and newborn animals. Studies on calving grounds suggest calving caribou select areas exhibiting rapid plant growth rather than specific areas or habitats. Although caribou on the North Slope tend to calve in the same general area year after year, frequently used migration routes may suddenly be abandoned in favor of movements to new areas where vegetation has recently emerged after snowmelt (Harper and McCarthy 2015).

During the summer, caribou eat willow leaves, sedges, flowering tundra plants and mushrooms. During the winter, they move to winter ranges where energy rich lichens (reindeer moss), dried sedges, and small shrubs are available (Harper and McCarthy 2015; Person et al. 2007). Caribou cope with this low protein diet in the winter by conserving and redistributing protein reserves and metabolites (Person et al. 2007 citing Gerhart et al. 1996 and Parker et al. 2005).

The caribou calving season depends on degree of daylight, as opposed to temperature, which makes it fixed at a certain time of the year. For northern herds, calving occurs in late May or early June, and usually results in a single calf being born as twins are very rare. Parturition rate and calving success rate are highly dependent on the female's body reserves and protein intake. The protein to energy ratio of forage consumed during lactation increases the milk protein intake by calves, which is the most important milk nutrient affecting calf growth at all calf ages (Griffith et al. 2002 citing White 1992). Females with high body protein in late winter produce the largest calves. However, if forage intake is not sufficient to meet a minimal rate of body protein deposition, the female will not be able to meet the lactation demands of her calf, which may cause early weaning that could negatively impact calf survival (Griffith et al. 2002).

After calving, caribou gather into large post-calving aggregations to avoid predators and insects such as mosquitoes and oestrid flies. Insect harassment can negatively impact calf growth as disturbances cause lactating females to substantially reduce foraging time due to increased movement rates when trying to escape harassment by insects. In August, insect numbers decline and caribou begin to spread out, focused on feeding heavily to regain body weight (Harper and McCarthy 2015).

Caribou movement between and within seasonal ranges are triggered by several factors throughout the year including changing weather conditions such as the onset of cold weather or snowstorms, onset of insects, and availability of adequate food. Larger herds may migrate up to 400 miles between summer and winter ranges while smaller herds may not migrate at all. Once they undertake migration, they can travel up to 50 miles a day (Harper and McCarthy 2015). (*See* figure 4.4)

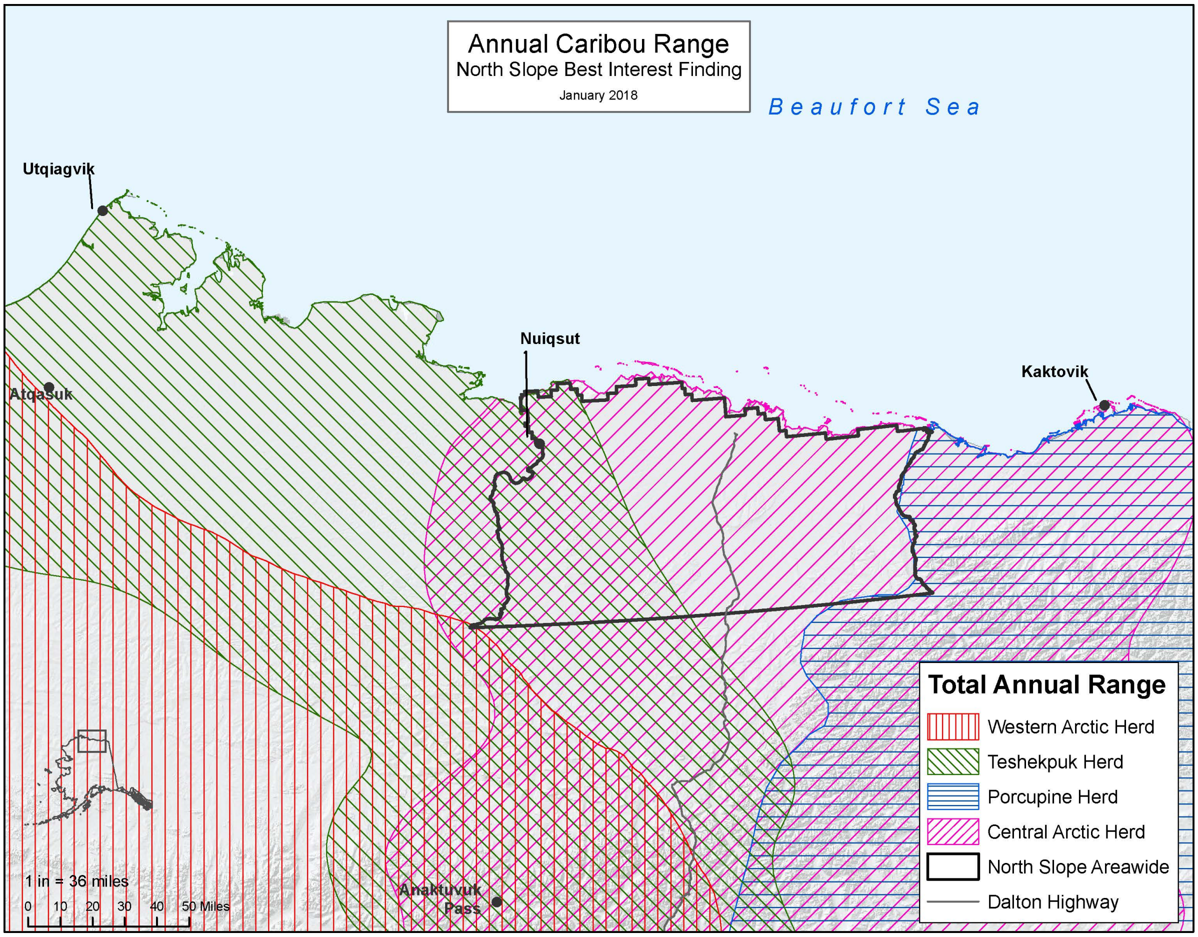

Figure 4.4.—North Slope caribou range.

Western Arctic Caribou Herd

The Western Arctic caribou herd (WAH) ranges over approximately 157,000 square miles in northwestern Alaska, from the Chukchi coast east to the Colville River, and from the Beaufort Sea coast south to the Kobuk River (Dau 2015). In winter, the range extends as far south as the Seward Peninsula and Nulato Hills, and as far east as the Sagavanirktok River north of the Brooks Range and the Koyukuk River south of the Brooks Range. This range includes the entire NPR-A, which the WAH use primarily during summer in the calving and insect relief seasons, although since 1996 several thousand WAH animals have summered on the Seward Peninsula. Caribou from the WAH and Teshekpuk caribou herd (TCH) mingle annually where seasonal ranges overlap. Caribou from this herd have also been known to mix with Seward Peninsula reindeer, which could become more common as the WAH expands into the Seward Peninsula, upper Kobuk, or Koyukuk drainages (Dau 2015; Mager et al. 2013).

In April, pregnant cows begin their spring migration from the overwintering areas to the calving grounds. Their northward movement through the Brooks Range often follows the most direct route, though certain routes may be used during calving migrations because they tend to be snow-free or snow shallow corridors. The WAH has exhibited strong fidelity to its calving grounds in the Utukok hills since the late-1950s. However, calving concentrations may shift gradually year-to-year or change abruptly due to environmental conditions and population size (Hinkes et al. 2005; Dau 2015). Typically, most pregnant cows reach the calving grounds by late May, but severe weather and deep snow can delay spring migration with some caribou calving en route. Cows calving en route usually proceed to their traditional calving grounds, although this may have a detrimental impact on calf survival (Dau 2003; Person et al. 2007).

Seasonal movements and distribution of WAH differ between bulls and cows. During spring, most cows travel north toward the calving grounds in the Utukok Hills, with bulls and nonmaternal cows moving toward the Wulik Peaks and Lisburne Hills (Dau 2015). Generally, bulls do not enter calving grounds during their spring migrations, and sexual segregation is more pronounced during that time of the year more than any other. The WAH calves mainly inland on the NPR-A. During the summer, the WAH uses the western North Slope and Brooks Range (Dau 2015).

For many years, the WAH exhibited a consistent pattern of movement during the summer (Dau 2015). By mid-June, after calving, cow and calf groups move west into the Lisburne Peninsula. In late June, when mosquitos begin to emerge, any bulls and non-maternal cows that have not already done so also arrive on the western North Slope to join the cow and calf groups. In early July, mosquito harassment intensifies and oestrid flies begin to emerge, causing most of the herd to form into large aggregations. As insect harassment continues during late-July and early-August, the WAH move rapidly back east toward the Howard and Anaktuvuk passes through southern NPR-A (Dau 2015). The caribou begin to disperse in early- to mid-August as insects diminish. Fall migration begins as early as mid-August and extends until caribou reach their winter ranges in November. As caribou move southwest toward the winter range, the herd becomes more dispersed than it is at any other time of the year. During winter, migratory movements cease and the animals become relatively sedentary until spring migration in April (Dau 2015 citing Hemming 1971).

Although the WAH experienced a period of continued decline between 2003 and 2013, the herd is still very large. Between 2011 and 2013, the WAH population decreased significantly from an estimated 325,000 to 235,000 caribou. While this decline is substantially higher than the annual rate of four-to-six percent observed between 2003 and 2011, the adult mortality rate suggests the rate of decline for those two years was not constant. Instead, mortality was very high in 2011 at 33 percent and only 20 percent in 2012. In addition to high mortality during 2011, recruitment was low during 2012 and 2013 (Dau 2015). A photocensus was conducted in 2016 and showed a minimum population count of 194,863 and a Rivest-based abundance estimate of 200,928 (ADF&G 2016g).

There is no evidence that any single factor such as hunting, predation, environmental contaminants, range degradation, or disease is currently limiting the size of this herd. Icing events, deep snow and harsh winter conditions like those in 2011 and 2012 likely caused high mortality in some years, and may have initiated this population decline. Adult cow mortality was relatively low during 2013–2014 (15 percent) and 2014–2015 (17 percent), in which both years had only light snow that came late in the winter. Opportunistic observations by researchers, and reports from local residents and long-term commercial operators, suggest that brown bears and, especially, wolves, have been abundant and successful in taking many caribou. Research suggests that predators are affecting the population dynamics of the WAH to a greater degree as of 2015, than in the previous 30 years (Dau 2015).

Porcupine Caribou Herd

The Porcupine caribou herd (PCH) ranges over approximately 130,000 square miles of remote, roadless wilderness. Adjacent to the Sale Area, the herd migrates between Alaska and the Yukon and Northwest Territories in Canada, and can be found south from the Beaufort Sea coast and from the Canning River eastward into Canada. Spring migration to the calving grounds begins in mid-April and continues through May. Data collected between 1983 and 2014 on calving distribution show sizes and locations were quite variable. The PCH's calving range is along the Beaufort Sea coast from the Canning River to the Babbage River in Canada (Griffith et al. 2002; Caikoski 2015).

In late June and early July, the herd departs from the annual calving grounds and begins to move toward the fall and winter ranges. Mosquitoes and oestrid flies are known to harass caribou, although harassment by oestrid flies may occur primarily after the PCH leave the calving ground (Caikoski 2015; Griffith et al. 2002). The PCH tends to prefer dry prostrate shrub vegetation types on ridge tops in the foothills and mountains of the Brooks Range, elevated sites on the coastal plain, and areas adjacent to the Beaufort Sea coast to gain relief from mosquitoes. PCH do not display as strong of a tendency to move to the coastline during potential insect harassment as has been observed for the adjacent CAH (Caikoski 2015; Lenart 2015b).

The fall migration may begin any time from late July to early August with the herd moving from the coastal plain to the Richardson Mountains or Old Crow Flats in northern Yukon. In August and September, the herd becomes widely distributed over a large geographical area extending from the Aichilik River to the Yukon-Northwest Territories border north of the Continental Divide and from the Coleen River to the Richardson Mountains south of the Continental Divide. By early October, the majority of the herd has moved west to the East Fork Chandalar River drainage with the remaining caribou moving south to the Ogilvie Mountains in Yukon (Caikoski 2015; Lenart 2015b).

Before 2013, the PCH wintered in three discrete regions; the Old Crow Flats in Yukon and the upper Coleen River drainage in Alaska, the Ogilvie Mountains, and the North Fork Chandalar River drainage. Wintering in these discrete areas limited the potential of the PCH to mix with other herds; however, animals that wintered in the North Fork Chandalar River drainage were mixed with caribou from the CAH. Between 2013 and 2014, data obtained from satellite and GPS collars showed the PCH split with 50 percent of the herd wintering in the Ogilvie Mountains in Yukon and 50 percent wintering in the upper Chandalar River or Hodzana Hills in Alaska. This change in location increased mixing with numerous other herds. In Alaska, PCH mixed with Central Arctic, Hodzana, and Teshekpuk caribou. It is unknown whether the shift in winter range is habitat-related or caused by some other disturbance (Caikoski 2015).

The PCH likely peaked near 178,000 caribou in 1989 and declined to 123,000 by 2001. Estimates of population size could not be obtained during 2002 and 2009 due to inadequate survey conditions. Successful photo censuses were completed in 2010 and 2013, and the herd was estimated at 169,000 and 197,0000 caribou respectively. Based on the 2013 population estimate, the PCH grew at an average annual rate of five percent from 2010 to 2013. The 2013 photo census was the highest ever observed for the PCH, indicating that the herd likely grew at an average annual rate of approximately three percent since 2001, although rates may have varied substantially during that period (Caikoski 2015). In 2015, caribou were radiotracked to evaluate photocensus conditions, but it was determined that the PCH and CAH were too mixed to conduct a photocensus. Researchers attempted another photocensus in 2016 but were not successful. Based on available data as of 2016, researchers estimate the PCH population is stable or increased slightly from the 2013 population estimate of 197,228 animals (Lenart 2017). Photocensus compiled in 2017 estimated record levels for the herd reaching 218,000 animals.

Central Arctic Caribou Herd

Recognized as a discrete herd in the mid-1970s, the range of the Central Arctic caribou herd (CAH) extends from just west of the Colville River to the Canadian border, the north side of the Brooks Range from the Itkillik River to the Canadian border, the south side of the Brooks Range from approximately the North Fork Koyukuk River to the East Fork Chandalar River, and as far south as the Chandalar River valley (Lenart 2015b citing Cameron and Whitten 1979). Because the full range of the CAH covers approximately 32,642 square miles, and includes the entire Sale Area, the CAH is in regular and direct contact with surface development related to oil production and transport. Its calving ground and summer range lie within the oil-field region near Prudhoe Bay, and its autumn, winter, and spring ranges encompass the Dalton Highway and the area around the Trans-Alaska Pipeline (National Research Council 2003; Nicholson et al. 2016).

The CAH traditionally calves between the Colville and Kuparuk rivers on the west side of the Sagavanirktok River and between the Sagavanirktok and Canning rivers on the east side (Lenart 2015b; Nicholson et al. 2016). During the early 1990s, the greatest concentration of caribou that calved in western GMU 26B shifted southwest as development of infrastructure related to oil production occurred in what was originally a major calving area (Lenart 2015b citing Lawhead and Johnson 2000 and Wolfe 2000). No directional shift in distribution of caribou that calves east of the Sagavanirktok River was noted (Lenart 2015b). Lesser used calving areas have also been identified in the area between the eastern channel and the Nechelik channel of the Colville and in the foothills of the Brooks Range, south of the Colville River delta (Lenart 2015b citing Cameron et al. 1992). Use of calving habitat varies with weather and snow conditions. The fidelity of caribou to their calving areas suggests that certain areas, such as those mentioned above, may be more important than other seasonal ranges (Harper 2013; Lenart 2015b).

The CAH summer range extends from Fish Creek, just west of the Colville River, eastward along the coast and inland approximately 30 miles, and spends June through mid-August near the Arctic coast between the Colville and Canning rivers (Griffith et al. 2002; Lenart 2015b). In midsummer, from mid- to late June through July, caribou are often harassed by mosquitoes and oestrid flies. Movement and habitat selection during the summer are closely tied to insect harassment. When mosquito harassment is high, caribou tend to select areas closer to the coastline than when oestrid fly harassment is high (Wilson et al. 2012). Large groups of caribou have been observed along the Beaufort Sea coastline, near Franklin Bluffs, on oil field roads and gravel pads, and on the deltas of the Canning, Kadleroshilik, Kuparuk, Sagavanirktok, Shaviovik, and Staines rivers. (Person et al. 2007; Lenart 2015b). Additionally, caribou avoided riverine vegetation when mosquito harassment was high, but selects these areas during periods of high oestrid fly harassment (Wilson et al. 2012; Lenart 2015b). The frequency and duration of caribou movements to and from the coast depend on different behavioral responses to insect species, and weather-related changes that affect the number of mosquitoes (Wilson et al. 2012; Lenart 2015b). Caribou distribution on the coastal plain can change dramatically within a 24-hour period.

The fall migration south begins in September and ends by mid-November. During both the spring and fall migrations, the CAH tends to move along or near major river drainages, such as the Itkillik, Kuparuk, Shaviovik, and Canning. They generally winter in the northern foothills of the Brooks Range, although substantial numbers have wintered south of the Brooks Range in recent years. Occasionally, caribou remain on the coastal plain during mild winters, and some will move onto the WAH range. Mixing with the WAH was documented in 2011 when portions of the WAH, Teshekpuk Lake herd (TCH), and PCH wintered on the south side of the Brooks Range, east of the Dalton Highway (Dau 2015; Lenart 2015b).

Mixing with TCH caribou frequently occurs in both summer and winter as herd ranges overlap along the Colville River in summer and early fall. Since 2004, one to five radio-collared TCH cows have calved with the CAH, and these animals have been documented frequently switching between the TCH and CAH from year to year. Additionally, near the Colville River drainage, some cows calve between the TCH and CAH core calving grounds or on the boundary of the summer ranges and may spend the summer with either herd. Between late summer and early fall of 2014, a portion of the CAH remained on the coastal plain and migrated with the TCH during rut and remained with the TCH through the winter (Lenart 2015b).

Mixing with the PCH has been documented where summer and winter ranges overlap along the Canning River. Mixing with the PCH during fall and winter occurred frequently between 2001 and 2011. Mixing during summer occurred less frequently between 2002 and 2009, but mixing of postcalving aggregations during summers in 2010 and 2011 occurred along the coastal plain between the Canning River and Kaktovik (Lenart 2015b citing Lenart 2013). In 2013, approximately 11 percent of PCH mixed with CAH during postcalving in early-summer on the coastal plain between the Canning River and the Hulahula River. Substantial mixing also occurred during rut and early winter west of the East Fork Chandalar River in 2013. In 2014, substantial mixing occurred during late winter-and early spring west of the East Fork Chandalar River and again during early summer postcalving on the eastern coastal plain near the Canning River. Some mixing occurred during rut, substantial mixing occurred near the East Fork Chandalar River during winter (Lenart 2015b).

From the initial population estimate in 1975 to 2000, the CAH steadily increased from 5,000 animals to more than 27,000 animals. This upward trend continued and in 2010, the herd was estimated at 70,034 caribou. Between 1998 and 2010, the CAH increased at a rate of approximately 12 percent annually. Studies suggest the increase was due to low adult mortality, high parturition rates, and good fall calf recruitment. A photocensus was conducted in 2013 and after adjusting for the radio-collared PCH caribou included in the minimum count, the CAH population was estimated at 50,753 caribou (Lenart 2015b). Researchers note that population estimates between 2008 and 2013 should be viewed with caution as few data points were available to make conclusive determinations as to population trends during that time. Additionally, a very late spring occurred in May 2013 that resulted in high mortality of adult and yearling females, which was reflected in the 2013 photocensus, resulting in a lower population number (Lenart 2015b; Nicholson et al. 2016). A photocensus was conducted in 2016 and the Rivest abundance estimate concluded the CAH population was approximately 22,630 animals. Researchers determined that most of the CAH decline was due to higher mortality of adults between 2013 and 2017 as compared to mortality rates before 2013 (Lenart 2017). Research suggests that the CAH population likely peaked between 2008 and 2012, and was either stable, or slightly decreased during 2008 and 2013; however, two additional population estimates are needed to make a more conclusive determination regarding the population trend since 2008 (Lenart 2015b).

Teshekpuk Lake Herd

The TCH occupies the area west of the Colville River, although its range extends to the Nulato Hills to the south, the Arctic National Wildlife Refuge to the east, and the Chukchi Sea to the west (Parrett 2015). The TCH are characterized by general patterns of seasonal movement coupled with highly diverse wintering areas (Person et al. 2007).

Calving occurs between May to late June near Teshekpuk Lake. Results of satellite telemetry studies, VHF radiotracking flights, and composition surveys between 1994 and 2012 indicate that the areas particularly south, east, and north of Teshekpuk Lake have historically been the highest density calving areas used by the TCH. TCH caribou that winter near, or with, the CAH or WAH frequently calve with those herds, resulting in a broad cumulative calving distribution (Parrett 2015). Apparent emigration of TCH caribou to neighboring WAH and CAH calving areas has been observed at a rate of 6.9 percent, although birth locations, and thus natal herd identity, of the dispersers were unknown (Mager et al. 2013).

The TCH uses the area north of the Teshekpuk Lake for insect relief and grazing. The narrow corridors of land to the east and northwest of the lake are important migratory pathways to and from the insect relief area (Parrett 2015 citing Yokel et al. 2009; Wilson et al. 2012; Yokel et al. 2008). Both satellite and GPS collar data show a tendency for TCH caribou to move in a clockwise pattern around the lake, although caribou do move in both directions through both corridors. Temperature and wind speed may explain the timing of movements to the north of Teshekpuk Lake, and wind may also influence this clockwise pattern. Studies suggest that during low insect activity, caribou tend to move with the prevailing northeasterly winds as they forage and head away from insect relief areas (Wilson et al. 2012). When insects increase, caribou return to relief area heading upwind. Headwinds decrease insect harassment during the return trip to insect relief areas. Movement rates are fastest during July, when mosquito activity is greatest. After July, movements are slower north of the lake, where mosquito activity is lower, than inland where greater mosquito harassment occurs. Caribou from the Teshekpuk Lake herd have also been observed in the Colville River delta seeking relief from insect harassment (Parrett 2015).

The Bureau of Land Management (BLM) has acknowledged the importance of the Teshekpuk Lake area and the two constricted zones to the TCH by their inclusion in the Teshekpuk Lake Special Area created in 1998. The federally-managed area protects important TCH habitat and migration routes by restricting the type and location of certain development activities (Person et al. 2007).

Overlap of the TCH with the WAH and CAH is common during fall and winter. Before 1990, the TCH was believed to reside year-round in the Teshekpuk Lake Area (Person et al. 2007). Satellite collar data collected since 1990 indicate that between 1990 and 2003 the majority of the TCH wintered on the coastal plain especially around Atqasuk and southeast of Teshekpuk Lake, but in some years, portions of the heard have migrated as far south as the Nulato Hills, Point Hope to the west, or the central Brooks Range near Anaktuvuk Pass to the southeast (Parrett 2015; Person et al. 2007). In 2003 and 2004, a significant portion of the herd moved to the ANWR to the east (Person et al. 2007). During the winters between 2011 and 2014, caribou were primarily concentrated near Atqasuk and Wainwright and to the east of Anaktuvuk Pass (Parrett 2015).

Population estimates between 1984 and 2011 show an exponential growth rate of seven percent for the herd; however, the 2013 population estimate of 32,000 caribou continues the decline first documented in 2011. Much like the adjacent WAH, adult female mortality in the TCH over the past two years was a strong contributor to the recent decline, which increased from a 5 percent annual decline to a 27 percent rate of decline between 2011 and 2013. Based on recruitment indices, adult mortality rates, and calf production, continued decline seems likely. However, results from a photocensus conducted in 2015 showed a minimum count of 35,181 animals and the Rivest abundance estimate was 41,542. Additionally, adult female mortality was estimated at 9 percent in 2015; lower than the long-term average of 15 percent, and among the lowest rate observed since 2000 (ADF&G 2016g).

An analysis of parturition and calving success rates in 2013 and 2014 showed that success rates were lower in 2013 and 2014, with a parturition rate of 28% and calving success rate of 16% for 2014, as compared to the long-term averages for parturition of 72% between 2002–2012, and 58% success rate for calving during 1999–2012 (Parrett 2015). Researchers suggest that a prolonged rate of parturition less than 55% may be indicative of a density dependent nutritional problem within the herd. The potential for immigration to influence and inflate populations remains a possibility, evidenced by the occurrence of collared caribou from neighboring herds during abundance estimates (Harper and McCarthy 2015). As the WAH, CAH, and TCH continue both temporary and permanent movement between herds, it is possible that more interchange will occur if density dependence induces caribou to seek a new range (Wilson et al. 2012; Parrett 2015; Mager et al. 2013; Harper and McCarthy 2015).

ii. Moose

Moose, specifically the Alaska-Yukon subspecies, are the largest member of the deer family. Widely distributed throughout Alaska, moose were scarce on the North Slope before the mid-1900s. Early studies suggested that predation and hunting contributed to the scarcity of moose in Arctic tundra areas. The subsequent expansion and establishment of moose populations in most of the riparian shrub habitat on the North Slope has been associated with the reduction in hunting due to the movement of Nunamiut people from inland/foothills to coastal locations in the 1920s and the reduction in wolf numbers by federal predator control programs during the 1940s and 1950s (Lenart 2014; Tape et al. 2016). However, recent studies evaluating habitat requirements of moose on the North Slope suggest that climactic fluctuations and the resulting shrub expansion in northern Alaska created habitat conditions that may have played a larger role in moose establishment on the North Slope than hunting reductions (Tape et al. 2016; Christie et al. 2014).

Moose on the North Slope area generally occupy narrow strips of shrub communities along drainages, except during calving and summer when some seasonal movement occurs away from riparian corridors. Adults can range in size from 800 pounds to 1,600 pounds, and stand almost six feet tall. Moose breed annually and females, or cows, typically breed at about 28 months. Calves are born from mid-May to early June after a gestation period of approximately 230 days. Cows usually give birth to a single calf, but twins can occur if food has been plentiful. Newborn calves can weigh in at approximately 30 pounds and grow to 10 times that size within five months.

The rutting season usually occurs in late September and early October. Growth patterns, age at sexual maturity, and production of offspring are closely tied to range conditions (ADF&G 2017). Historically, the greatest concentrations in GMU 26B and 26C occurred along the Canning, Kavik, Ivishak, Toolik, Kuparuk, Itkillik, and Kongakut rivers, and Juniper and Fin Creeks (Lenart 2014). Moose movements have not been intensively studied, but surveys indicate there may be movements between or within North Slope drainages. Moose in the Colville River area are resident rather than seasonally migratory (Lenart 2014 citing Carroll 2004).

Moose feed selectively on relatively high-quality riparian shrubs, particularly willow. However, there has been a marked change in shrub production on the North Slope. Between 1950 and 2000, floodplain riparian shrub cover in northern Alaska increased from 5 percent to 13 percent. In tundra and arctic regions, the availability of forage shrubs above the snow can limit moose distribution. Moose use dense woody vegetation as cover to reduce detection, and as protection during wolf attacks. Moose on the North Slope are limited by winter range, and spend 80 to 90 percent of their tracked distance during winter in habitats with shrubs taller than three feet, and the remainder on frozen riverbeds between thickets. (Tape et al. 2016).

During the late 1940s to 1950s, moose populations expanded and became established along the riparian shrub corridors of the Colville River and its tributaries (Lenart 2014 citing Leresche et al 1973). An aerial population survey in late-winter of 1950 revealed 109 moose along a 55-mile section of the Colville River floodplain. Extensive late-winter surveys in 1970 and 1977 covering most of the North Slope from Utukok to Kongakut River recorded between 1550 and 1700 moose, with approximately half of those moose residing in the middle Colville drainage (Tape et al. 2016 citing Coady 1980 and Carroll 2011). It is estimated that moose populations in GMU 26B and 26C peaked at approximately 1,400 during the late 1980s (Lenart 2014 citing Martin and Garner 1984 and Mauer and Akaran 1994). Moose populations declined dramatically in the early-1990s across the North Slope. Winters between 1993 and 1995 were long, resulting in shorter growing seasons for favored vegetation. Calf survival was very low during 1993 to 1996. In 1996 and 1997, the bacterial diseases brucellosis and leptospirosis were found in live moose, and a marginal copper deficiency was reported in many of the live and dead moose sampled. It is possible that poor environmental conditions increased vulnerability to disease during the early 1990s, and disease may have increased vulnerability to predation (Lenart 2008, 2014).

Beginning in 1999, the shifting moose population within the Sale Area, and combined survey data for GMU 26B East, 26B West, and the Itkillik River drainage trend areas indicated a gradual increase during 2003 to 2008. In spring 2010 and 2011, researchers observed approximately 100 fewer moose than the 564 moose that were observed in spring 2009. The combined counts for all of GMU 26B show researchers observed 464 moose in 2011, 396 moose in 2012, and 109 moose in 2013 (Lenart 2012). It is unclear what caused the decline, but consecutive years of low recruitment beginning in 2008, coupled with moderately deep snow levels in 2009, may have had an influence on moose condition or vulnerability to wolves, and contributed to numerous moose kills observed during a spring 2010 survey. In central GMU 26C, moose numbers remained stable during the 2000s, while numbers in eastern GMU 26C were higher in early winter 2011 than observed in early winter 2000 (Lenart 2010, 2012).

In spring 2014, the moose population in the Sale Area experienced another severe decline. From 2013 to 2014, the population in GMU 26B declined by approximately 75 percent with no short yearlings observed in spring 2014. Similarly, the population in central GMU 26C declined by approximately 50 percent with no short yearlings observed. There was a slight increase in 2016 with 138 moose observed in GMU 26B (Lenart 2017). Studies show the severe decline from 2013 to 2014 may have stemmed from poor nutrition due to a very late spring in 2013, resulting in high adult mortality and little or no recruitment. Predation by wolves on weakened moose may have also contributed to the population decline since few alternate prey inhabit GMU 26B and central GMU 26C during winter (Lenart 2014). Population dynamics are commonly influenced by predation, disease, and weather, but suitable climate and habitat facilitate the establishment and persistence of populations, thereby shaping the regional distribution of moose. Given the North Slope represents the northern limit of moose range in North America, moose populations in the Sale Area are more vulnerable to climatic or nutritional stresses (Lenart 2014; Tape et al. 2016).

iii. Brown Bears

Brown and grizzly bears are classified as the same species even though there are notable differences between them. The term "brown bear" commonly refers to animals found in coastal areas, while the term "grizzly" is often used when referring to brown bears found inland and in northern habitats (ADF&G 2008). For this finding, the term "brown bear" will be used to describe members of *Ursus arctos* in the North Slope region.

Brown bears are widely distributed in the North Slope region. Densities are generally highest in the foothills, moderate in the Brooks Range Mountains, and lowest on the BCP (Lenart 2015a). Bear density generally reflects food availability, suggesting that on the BCP, lack of an abundant and predictable food resources limits the population (Lenart 2015a citing Ferguson and McLoughlin 2000; Bentzen et al. 2014). Brown bears on the BCP prefer riparian habitats as these areas provide the greatest diversity of food. Natural prey available in the Sale Area include arctic ground squirrels, musk ox, caribou, and numerous species of water birds. Bears feed extensively on roots of sweet vetch in spring and autumn and arctic lupine in summer; graminoids, sedge, and cottongrass in early summer; and flowers or leaves of forbs and coltsfoot during mid-summer (Bentzen et al. 2014). Since the main oil field region is situated between the Sagavanirktok and Colville rivers, two of the largest riparian areas on the North Slope, brown bears have ample opportunity to encounter oil field facilities and activities (Lenart 2015a).

Brown bear weights vary by age, gender, location, and time of year. Cubs weigh about one pound at birth and attain adult size by age six. A large male may weigh up to 1,500 pounds in coastal areas or up to 500 pounds in interior areas, and tend to be approximately 30 to 50 percent larger than females. Mating season occurs from May to July, and cubs are born in the den during January and February, emerging in June (ADF&G 2016c). Twins are most common, but studies have identified a correlation between litter size and mean adult female body mass (Bentzen et al. 2014; Zedrosser et al. 2011). While most brown bears are sexually mature at age five, females often do not successfully produce a litter until later (ADF&G 2008). On the North Slope, data collected from 116 marked bears between 1992 and 2004 indicates that females that had access to human food were younger at the age of first reproduction compared with those that fed on natural food only, approximately 5.5 years old and approximately 7.5 years old respectively. Additionally, the mean reproductive interval for food-conditioned bears was 1.5 years lower than natural-food bears, 3.3 years compared to 4.8 years respectively (Bentzen et al. 2014; Lenart 2015a).

Den selection and use is an important component of bear ecology. Bear hibernation is generally attributed to limited food resources during winter when bears reduce energetic costs by reducing metabolic rates. Studies have identified several factors that play an important role in den site selection and denning behavior. Bears choose dens sites based on several factors, including den aspect, slope, and habitat characteristics such as vegetation cover and soil substrate. On the BCP, brown bear dens occur in pingos, banks of rivers and lakes, sand dunes, steep gullies in uplands, and use a southern aspect (Reynolds et al. 1976; McLoughlin et al. 2002).

Den site selection and behavior also differed between adult females and adult males. Studies suggest that intraspecific predation, in which adult males have killed juveniles and adult females, may influence denning behavior. A study of denning behavior between 1990 and 1998 shows adult females select dens at higher elevations than adult males. While the mechanism for male den site selection is unknown, studies suggest that the range of elevations selected by males is related to the food availability at den emergence. In this case, den site elevation uses of adult male brown bears overlapped extensively with the elevation range of the caribou calving ground (Libal et al. 2011).

In addition to spatial segregation, adult females enter dens earlier and emerge later than adult males. Adult females, particularly those with young, delay denning to maximize foraging opportunities before winter as percentage of body fat in fall influences proportion of lean body mass lost during hibernation, and therefore animal condition. Adult females may remain in high elevation dens to conserve energy, where longer snow cover increases thermal insulation and reduces energy loss, and wait for adult males to disperse from den areas and more dispersed food to become available (Libal et al. 2011). In a study of denning behavior, data collected between 1990 and 1998, shows the duration of denning of males of 184.6 days was significantly less than that of females of 198.6 days. Females enter dens on an average of nine days earlier than males, and emerge from dens on an average of six days later than adult males (McLoughlin et al. 2002).

Early oil and gas exploration and an increase in aircraft supported guided hunters in the 1960s caused a decline in brown bear populations on the North Slope. As a result, in regulatory year 1971, Units 26B and 26C were closed to brown bear hunting. In subsequent years, a variety of regulations were used to limit harvest and increase brown bear populations. As populations recovered, regulations have been gradually relaxed, and brown bear populations across the North Slope have been relatively stable since the late 1980s.

As of 2017, brown bear populations in Unit 26B are managed to liberalize hunting seasons, reduce predation on muskoxen in accordance with 5 AAC 92.126, and maintain an estimated population of 200–320 bears. Although there were no bear population surveys conducted in GMU 26B or 26C in 2012 or 2013, researchers extrapolated data collected from previous surveys to estimate brown bear populations for 2015. Population data released in 2015 for GMU 26B was based on a double-count line transect population estimate conducted in a portion of GMU 26B between 1999 and 2003, and estimates there are approximately 265 brown bears at an estimated density of 1.7 bears per 100 square miles in GMU 26B. The 2015 population estimate for GMU 26C of 391 brown bears at an estimated density of 3.8 bears per square mile is based on the 1993 estimate of approximately 390 brown bears. Availability of habitat for brown bears in this area has not changed substantially since 1993 (Lenart 2015a).

iv. Muskoxen

Before the mid-1800s muskoxen were widely distributed across the Arctic, but by the early 1900s Alaska's original population had been eliminated. Overharvesting was originally thought of as the cause for decimated Alaska populations; however, research suggests that climactic fluctuations may have played a significant role (Markova et al. 2015; Campos et al. 2010). In 1935, a group of 34 muskox that had previously been captured in East Greenland were transferred to Nunivak Island. Between 1969 and 1970, 51 animals from Nunivak Island were released on Barter Island, and 13 were released at Kavik River on the eastern North Slope (ADF&G 2016d; Lenart 2015c). During the 1970s and 1980s the number of muskoxen within GMU 26C increased steadily and expanded eastward into Yukon, Canada, and westward into the Sale Area in GMU 26B and eastern Unit 26A during the late 1980s and early 1990s (ADF&G 2012; Lenart 2015c). By the mid-1990s, populations in Unit 26B and 26C appeared to be stable at around 600 with an additional 100 animals in Yukon, Canada (ADF&G 2012). Since 1999, muskox populations in GMU 26B and 26C have been in an almost constant state of flux, especially within Unit 26C where all of the animals had essentially disappeared by 2006 (ADF&G 2012; Lenart 2015c).

The muskoxen are a stocky, long-haired animal with a slight shoulder hump and a very short tail. Mature bulls are about five feet high at the shoulder and weigh 600–800 pounds. Females, or cows, are smaller, averaging approximately four feet in height and weighing 400–500 pounds. Breeding season begins during late summer, and mating takes place in August and October. Single calves weighing from 22 to 31 pounds are born between April and June to cows older than two years. Calves grow rapidly and can weigh between 150 and 235 pounds as yearlings (ADF&G 2016d).

Muskoxen are well adapted to Arctic environments but are extremely sensitive to both long and short term shifts in climate (Markova et al. 2015; Campos et al. 2010; Arthur and Del Vecchio 2013). Reproduction and survival is directly influenced by seasonal habitat use and energy budget (Arthur and Del Vecchio 2013; Klein et al. 1993). Muskoxen are poorly adapted for digging through heavy snow for food, which can significantly impact the availably of food and the energy cost of obtaining it. Nutritional stress can prevent cows from reproducing on an annual basis, and in some cases a cow can go multiple years without successfully producing a calf (Arthur and Del Vecchio 2013; Klein et al. 1993; Lenart 2015c). Winter habitats are limited to areas where snow is either shallow or patchy with areas of accessible forage such as dried grasses, sedges, and willows. In summer, muskoxen prefer streams and vegetated valleys that offer a wide variety of plants. Muskoxen are mainly distributed along the Sagavanirktok, Kuparuk, Colville, and Canning rivers, with the two largest concentrations found near the Arctic coast south and east of Deadhorse and northwest of Prudhoe Bay in the vicinity of Beechey Point (Arthur and Del Vecchio 2013; Lenart 2015c).

The overall population size in GMU 26B and 26C declined considerably between 2001 and 2007, but the population dynamics differed between the two units. For example, abundance of calves, yearlings, and adults began declining in GMU 26C in 1999, but the abundance of calves and yearlings documented within GMU 26B remained stable from 1999 to 2006 (Arthur and Del Vecchio 2013; Lenart 2015c). Even though the population composition appeared stable in GMU 26B, total population in that unit declined between 2003 and 2006 to 216 muskoxen (Lenart 2015c). From 2007 to 2011, ADF&G research staff documented that brown bear predation on muskoxen was a primary source of mortality for muskoxen in GMU 26B. In April 2012, ADF&G implemented a muskox recovery program in GMU 26B that authorized a predation control plan to reduce the effects of brown bear predation on muskoxen by selectively removing brown bears threatening or killing muskoxen. In 2012, studies indicated that removing brown bears would result in a population increase. However, the population remained relatively unchanged following two years of intensive monitoring when brown bears threatening or killing muskoxen were lethally removed (ADF&G 2012; Arthur and Del Vecchio 2013; Lenart 2015c). The GMU 26B population has remained relatively stable at approximately 190 muskoxen from 2007 to 2015 (Lenart 2015c). A slight increase was identified in 2016 with 219 muskoxen counted in GMU 26B (Lenart 2017).

b. Furbearers

Furbearers are species of terrestrial mammals that are routinely sought by trappers who place commercial value on the pelts. Although detailed information about furbearer abundance and species composition on the Arctic Slope is limited, overall, GMU 26 supports extensive populations of a variety of furbearers, especially beaver, lynx (cyclic), and red fox. Other furbearers found in or adjacent to the Sale Area include wolves, Arctic fox, marten, mink, weasel, muskrat, and wolverine. Wolf, wolverine, and Arctic fox are the most important species for trappers on the Arctic Slope (Carroll 2013; Caikoski 2013).

Lynx established themselves on the North Slope during the 1990s after snowshoe hares became plentiful in the Colville River drainage. Only occasional lynx sightings were made through 2000, but numbers increased in 2001 and 2002 and lynx were seen as far north as Wainwright and Utqiaġvik (Caikoski 2013). Before 2005, red foxes were only seen in interior areas, but are now being seen more often as far north as Utqiaġvik (Carroll 2013; Stickney et al. 2014). Due to limited habitat, marten and coyote are rare on the North Slope but may occasionally be seen near the southern boundary of the Sale Area (Carroll 2013).

Between 2009 and 2012, no specific furbearer population surveys were conducted in GMU 26 (Carroll 2013). Population status has been monitored through trapper questionnaires, interviews, pelt sealing records, fur acquisition reports, export reports, anecdotal information from reliable observers, as well as recording incidental furbearer observations during surveys conducted for other species. In 2010, trappers reported that red fox were abundant in the interior regions of GMU 26A, Arctic fox were abundant along the coastal plain in GMU 26A, river otters were seen in low, but increasing numbers along the Colville River and some of its tributaries. Ermine and wolverine were scarce. Coyotes were occasionally seen along the southern border of GMU 26A (Caikoski 2013). Data from the 2013 trapper questionnaire for GMU 26B indicated an increasing trend in relative abundance for red fox and ermine, a decreasing trend for Arctic fox and wolverine, and no change in relative abundance for river otters (Schumacher 2013). However, as of 2013, quantitative population data was lacking on the status of most furbearer populations on the Arctic Slope, including red foxes, Arctic foxes, river otters, and coyotes (Caikoski 2013).

i. Wolves

Wolves are found throughout the Sale Area, using the BCP tundra, Colville River system, and Brooks Range mountain habitats (ADF&G 2016h; Caikoski 2012). Wolf packs can have a large range depending upon the availability of prey (caribou, moose, and Dall sheep). Wolves are highly social animals that tend to live in packs of six or seven animals and usually remain within an established territory ranging from 300 to 1,000 square miles (ADF&G 2016h). Wolves that target migratory caribou may temporarily abandon their territory and travel longer distances when necessary (Geffen et al. 2004).

Wolves normally breed in February and March, and pups are born in May. Litters may contain two to ten pups, but average around five, with younger females having fewer pups than older females. Pups are usually born in dens dug approximately 10 feet into well drained soil. Adult wolves generally center their activities near dens, but may travel up to 20 miles away from the den in search of food. Wolf pups are weaned gradually during midsummer, and transitioned away from the den in mid to late summer. By early winter, pups are capable of traveling and hunting with adult pack members (ADF&G 1994d, 2016h; Geffen et al. 2004).

Moose, caribou, and Dall sheep are wolves' primary food. During the summer, wolves may supplement their diet with small mammals including voles, lemmings, ground squirrels, snowshoe hares, beaver, and occasionally birds and fish. Wolves are also opportunistic feeders, preying upon very young, old, or diseased animals. However, even animals in their prime may be vulnerable to wolves under certain circumstances such as winters with unusually high snowfall (ADF&G 2016h; Geffen et al. 2004).

Despite a generally high birth rate, wolves rarely become abundant due to high mortality. Wolf population numbers throughout GMU 25 and 26 have fluctuated since the 1900s in response to changes in prey populations, a federal wolf control program in the 1950s, and aerial and snowmachine hunting by the public since the 1960s. Wolf populations in the mountains and foothills of the Brooks Range began to rebound after bans on aerial wolf hunting in 1970, and land-and-shoot hunts in 1982 (Caikoski 2012). Some of the highest wolf densities around the Sale Area occur along the Colville River and its tributaries (Carroll 2012).

The most recent population estimate for GMU 26A was made in 1993, and estimated the population at 240 to 390 wolves. Taking into account the population decrease between 1992 and 1996, the increase from 2002 to 2009, and assuming the lower density of the coastal plain, it is estimated that in 2012, the total number of wolves was probably similar to what it was in 1993 of 240 to 390 wolves (Carroll 2012). Based on results from wolf research studies and earlier surveys, extrapolation of population estimates from surveys in similar habitat, and harvest and prey population trends between 2008 and 2011, wolf populations in GMU 26B was estimated at 4.8 wolves per 1,000 square miles and in GMU 26C the population was estimated at 5.7 to 8.3 wolves per 1,000 square miles. As of 2012, wolf populations in the Sale Area appeared to be stable, but data on population trends are limited (Caikoski 2012).

ii. Arctic Fox

The Arctic fox is one of the most common furbearers found in the Sale Area and on the BCP. The Arctic fox is a year-round resident of the BCP. It is highly adapted for survival in such a very cold, strongly seasonal environment, where it remains active throughout the eight-month Arctic winter. Some of its cold-tolerant adaptations include thick fur, large fat reserves, a specialized heat-retaining circulatory system in its feet, and the ability to lower its metabolic rate to endure periods of starvation (Gallant et al. 2012).

Mating occurs in early March through early April. Litters average seven pups, but may contain as many as 15 pups. Arctic foxes are monogamous in the wild. Both parents aid in bringing food to the den and in rearing pups. Pups begin eating meat when they are about one month old and are fully weaned by six weeks. They emerge from the den when they are about one month old and are fully away from the den at about three months. Arctic foxes attain sexual maturity at 9 to 10 months, but many die in the first year (ADF&G 2016a).

Arctic foxes have prospered in the Prudhoe Bay oil field area, and readily use development sites for feeding, resting, and denning (Stickney et al. 2014; Pamperin et al. 2006). Population densities are greater in the oil fields than in surrounding undeveloped areas, suggesting that access to anthropogenic food sources may support a population increase (Savory et al. 2014; Stickney et al. 2014). A study that tracked winter movements of Arctic foxes fitted with satellite collars between 2004 and 2007 showed that Arctic foxes in the oil fields traveled approximately 33 miles per four-day duty cycle and approximately 8 miles per day during the winter months, while animals collared in the undeveloped areas of the NPR-A traveled approximately about 126 miles per duty cycle and approximately 31 miles per day. Juveniles and adults collared in NPR-A were highly mobile and made long distance movements of approximately 485 miles while foxes from Prudhoe Bay remained in or near the oil field throughout the winter (Tarroux et al. 2010; Pamperin 2008). Arctic foxes are particularly vulnerable to rabies and their populations tend to fluctuate with the occurrence of the disease (Carroll 2013).

The availability of winter food sources has a direct impact on fox abundance and productivity. The Arctic fox is considered as an opportunistic predator with a preference for microtine rodents (Tarroux et al. 2010 citing Elmhagen et al. 2000). Peak fox populations are associated with abundant lemming populations, their primary prey (Savory et al. 2014). Arctic foxes feed on voles and eggs year-round, while tundra-nesting birds form a large part of their diet during the summer (Pamperin et al. 2006; Savory et al. 2014). In Prudhoe Bay, Arctic foxes use anthropogenic food at a greater rate, particularly in late winter when 39 percent of Arctic fox diet is attributed to anthropogenic foods (Savory et al. 2014). Arctic foxes are known to venture on the sea ice to forage on ringed seal pups and the carcasses of other marine mammals. However, telemetry data from Arctic foxes in Prudhoe Bay show no use of sea ice, which is required for access to seal pups, and an analysis of tissue samples showed low tissue atmospheric nitrogen values, indicating ringed seals were not a contributing food source for foxes in Prudhoe Bay (Savory et al. 2014 citing Lehner 2012; Pamperin 2008).

Fox dens are widely recognized features of the Arctic landscape. Usually located in mounds, hills, pingos, or ridges, a typical natural den site has low snow cover, is above the water table, and has a deep active layer, stable surface, and sandy soil. Within the oil fields, foxes sometimes create dens in manmade structures including culverts, road berms, caribou crossings, and the undersides of elevated buildings. Because many dens are reused over decades, den locations have been mapped and monitored annually, providing an index of fox abundance and productivity. Studies conducted in the greater Prudhoe Bay area from the 1970s through the early 1990s focused mainly on Arctic foxes as red foxes were uncommon. However, recent research and data obtained from trapper questionnaires show that Arctic foxes are increasingly being displaced from dens, and as of 2013, there has been a declining trend in the number of observations (Schumacher 2013; Stickney et al. 2014). While the factors prompting the change are not clear, researchers suggest that multiple factors including direct aggression by red foxes, competition for resources, and climate change may be to blame. (Stickney et al. 2014; Savory et al. 2014).

iii. Red Fox

The red fox is found throughout most of Alaska, but is most abundant south of the Arctic tundra. It is also present in tundra regions, which is shared with the Arctic fox. Research suggests that resource availability determines the northern limit of the red fox's geographic range, partly because of the larger body size and greater food requirements of this species compared to the Arctic fox (Pamperin et al. 2006). Before 2005, red foxes were only seen in interior areas, but by 2012, red foxes were seen as far north as Utqiaġvik (Carroll 2013).

Red foxes breed during February and March. Their breeding habits vary, and males have been observed exhibiting monogamous breeding behavior as well as breeding with multiple females. Females give birth to litters ranging from one to ten pups, with a litter of four being most common. Normally only one litter is born each year, and pups are blind at birth. Pups are gradually weaned, and are learning to hunt by the time they are three months old. Both parents care for the young, and the family unit endures until autumn, when it breaks up and each animal is on its own (ADF&G 2016e).

Red fox dens are dug into the earth, 15 to 20 feet long, and usually located on the side of a knoll (ADF&G 2016e). A den may have several entrances. Sometimes red foxes will dig their own dens; but more often, they appropriate and enlarge the dens of small burrowing animals such as marmots or as is becoming more common on the North Slope, Arctic foxes. Red foxes will also use abandoned wolf dens (Stickney et al. 2014).

Red foxes were first observed in Prudhoe Bay in 1988, and in 1992, only one red fox den was recorded in the Sagavanirktok River delta. Previously Arctic foxes had occupied this den. In 2005, BP initiated a long-term monitoring program that included annual surveys for occupancy and productivity of fox dens in the greater Prudhoe Bay area. Between 2005 and 2012, studies show a rapid shift in den occupancy as red foxes displaced Arctic foxes from den sites and breeding territories. By 2010, the majority of monitored dens with breeding foxes were occupied by red foxes, and red foxes became the primary and dominant species in the greater Prudhoe Bay area (Savory et al. 2014 citing Streever and Bishop 2013).

The larger red fox can dominate and outcompete Arctic fox for forage and den sites, and at least one instance of a red fox killing an Arctic fox has been observed in Prudhoe Bay (Pamperin et al. 2006). Physical contact between the two species through fighting or predation also increases the chances of rabies transmission, as the Arctic fox is a known host of rabies in northern Alaska (Carroll 2013; Savory et al. 2014). Red foxes also have the potential to have a greater impact on prey populations than an equivalent Arctic fox population because they are larger, more aggressive, and have higher energy requirements than Arctic foxes (Gallant et al. 2012).

The red fox is omnivorous. Although it might eat muskrats, squirrels, hares, birds, eggs, insects, vegetation, and carrion, lemmings are the preferred food (ADF&G 2016e). The diet of the red fox varies with the seasons. During late summer, red foxes heavily consumed lemmings, which account for approximately 78 percent of their diet. Anthropogenic foods made up a small portion of the late-summer diet, accounting for approximately 11 percent of their dietary intake. Voles and eggs were also a small component of late-summer diet. Red fox diet during late winter differed considerably from that of late summer. There was a substantial decrease in the proportion of lemmings, although lemmings still accounted for approximately 43 percent of their diet. Intake of anthropogenic foods increased substantially during the winter and accounted for approximately 49 percent of their dietary intake. Red foxes ate little to no voles or eggs in their late-winter diets. The lifetime diet of red foxes as estimated from analyses of bone collagen was similar to their diet during late winter. The proportion of lemmings in their diet was approximately 43 percent. Use of anthropogenic foods was approximately 52 percent. There appeared to be little to no consumption of voles and/or eggs (Gallant et al. 2012; Pamperin et al. 2008; Savory et al. 2014; Stickney et al. 2014).

Exactly which ecological factors favoring the expansion of red foxes into Prudhoe Bay is unclear, but the availability of a food subsidy, and anthropogenic foods, has likely contributed to their success and persistence there. Dens occupied by red foxes tend to be closer to oil field facilities where the availability of anthropogenic foods, especially in the winter, may explain the year-round presence of red foxes in those areas (Savory et al. 2014; Stickney et al. 2014).

c. Marine Mammals

Marine mammals are aquatic mammals that rely on the ocean and other marine ecosystems for their existence. Marine mammal adaptation to an aquatic lifestyle varies considerably between species. Cetaceans, which include whales, dolphins, and porpoise, are fully aquatic, but need air to breathe. Pinnipeds, which include seals, sea lions, and walruses, are semi-aquatic. They spend most of their time in the water but return to land for mating, breeding, and molting. Pinnipeds are carnivores that use flippers for movement on land, ice, and in water. Marine fissipeds, which include polar bears and sea otters spend most of their time on land. Only part of their time is spent in water, mainly to hunt their food.

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA established a national policy to prevent marine mammal species and population stocks from declining beyond the point where they cease to be significant functioning elements of the ecosystems of which they are a part. Although all marine mammals are protected by the MMPA, protection of these species is split between the National Marine Fisheries Service (NMFS) and the USFWS. Co-management agreements between the NMFS, USFWS, National Oceanic Atmospheric Administration (NOAA), and Alaska Native organization have been formed under Section 119 the MMPA to establish co-management structures, monitoring of subsistence use, and cooperation in data collection and research on marine mammal populations. Co-management agreements with the Alaska Beluga Whale Committee, Alaska Eskimo Whaling Commission, and Ice Seal Committee have been established to date (NOAA 2018b).

i. Polar Bears

Characterized by large body size, a stocky form, and fur color that ranges from white to yellow, polar bears are the largest living bear species and the only one that is considered a marine mammal. Widely distributed across the ice-covered waters of the circumpolar arctic, polar bears occur in 19 relatively discrete subpopulations. Within this range, the species exhibits variation in genetics, behavior, and life history strategies (Muto et al. 2016; USFWS 2016a). Alaska contains portions of two subpopulations, the Chukchi Sea subpopulation and the Southern Beaufort Sea subpopulation.

The Chukchi Sea and Southern Beaufort Sea subpopulations are also known as the Alaska stocks. The presence of two separate stocks is based upon variations in levels of heavy metal contaminants of organ tissues, morphological characteristics, physical oceanographic features which segregate the Chukchi Sea stock from the Beaufort Sea stock, and movement information collected from mark and recapture studies of adult female bears (Muto et al. 2016 citing Lentfer 1974, 1976, 1983; Wilson 1976, Lentfer and Galster 1987). Studies on contaminants and movement data using satellite collars continue to support the presence of these two Alaska stocks (Muto et al. 2016 citing Amstrup et al. 2004, 2005; Muir et al. 2006, Kannan et al. 2007, Rush et al. 2008).

The Southern Beaufort Sea (SBS) stock inhabits the coast along the Sale Area, and the population is generally defined from Icy Cape, near Point Lay, on the west to just south of Banks Island and east of the Baillie Islands, Canada (IUCN 2018). However, there is an extensive area of overlap between the SBS stock and the Chukchi/Bering Sea stock that occurs between Point Barrow and Icy Cape (Muto et al. 2016). Polar bears are relatively long-lived and are characterized by late sexual maturity, small litter sizes, and extended maternal investment in raising young. These are all factors that contribute to a low reproductive rate. High adult survival rates, particularly of females, are required to maintain population levels. Survival rates exceeding 93 percent for adult females are essential to sustain polar bear subpopulations (USFWS 2016a citing Regehr et al. 2015).

Polar bears are competent swimmers, but depend on sea ice as a platform from which to hunt and feed on seals, seek mates and breed, travel to terrestrial maternity denning areas, den, and make long-distance movements. With the exception of individuals that den on the land, polar bears of the SBS stock have historically spent the entire year on the sea ice, even when the pack ice retreated away from the coast to its minimal extent in September (Atwood et al. 2016). Polar bear movements are closely tied to the seasonal dynamics of sea ice extent as it retreats northward during summer melt and advances southward during autumn freeze. This makes them vulnerable to reductions in the extent and duration of sea ice (USFWS 2016a; Atwood et al. 2016).

Summer sea ice conditions in the Arctic have changed with the minimum extent of summer sea ice decreasing 30% since the late 1970s (Miller et al. 2015 citing Stroeve et al. 2012). Polar bears rely on sea ice to hunt ringed seals, their primary prey, in the prey-rich shallow waters over the continental shelf. They tend to minimize time spent over deeper, less productive waters. Shorter periods of the year when sea ice is over the continental shelf reduces the amount of time bears can hunt, and has led to notable increase in time spent on land during the summer and autumn (Rogers et al. 2015; Miller et al. 2015). Research shows that the mean length of stay on shore during the open water period has more than doubled from a mean of 20 days onshore from 1986 to 1999, to a mean of 56 days onshore from 2000 to 2014 (Atwood et al. 2016).

In 2000, there was a notable increase in the proportion of radio-collared bears coming ashore in summer and fall; however, this was followed by a pronounced decline in survival between 2004 and 2007 and then two years of apparent stability between 2008 and 2009 (Rogers et al. 2015; Atwood et al. 2016). There are a number of hypotheses as to what caused the change in population, but several independent studies reported physiological indications of nutritional stress to be two to three times greater in 2005 and 2006 than in the 1980s (Bromaghin et al. 2015). Unusual behavior was observed between 2003 and 2007. This behavior included polar bears stalking and killing other bears, polar bear cannibalism, instances of energetically inefficient behavior such as polar bears penetrating unusually thick ice barriers to reach ringed seal lairs, as well as reported observations of starvation (Bromaghin et al. 2015 citing Cherry et al. 2009; Regehr et al. 2006; Amstrup et al. 2006; and Stirling et al. 2008).

Factors leading to improved survival beginning in 2007 are difficult to identify, but there are indications of a transition at this time. Studies report a shift in the distribution and number of seal kill sites among land-fast and pack ice between 2007 and 2011 (Bromaghin et al. 2015 citing Pilfold et al. 2014). Ringed seal productivity within the Amundsen Gulf in the eastern SBS was low in 2005 and 2006, but improved in 2007, likely attributed to localized ice conditions (Harwood; Smith; et al. 2012). Additionally, improved survival after 2007 might be partially attributable to either density dependent mechanisms, or behavioral changes of surviving individuals (Bromaghin et al. 2015).

While researchers are noticing a change in behaviors where some members of the SBS stock are opting to exploit terrestrial habitat, rather than remain with the retreating pack ice, this behavior is not surprising as it is common in other subpopulations where sea ice completely melts every summer. Whether the SBS stock will benefit from this behavioral flexibility will likely hinge on the trade-off between the availability of food resources and net energetic benefit, and the risks associated with accessing them such as increased exposure to human related activities, competition with brown bears, and increased potential for disease transmission (Atwood et al. 2016).

One study documented competitive interactions among polar bears and between polar bears and brown bears for bowhead whale remains deposited adjacent to Kaktovik. Researchers observed polar bears were more common at the feeding site than brown bears; however, during interspecific interactions, the most common scenario involved a nonaggressive approach by a brown bear that resulted in a submissive response by a polar bear. Brown bears were the dominant competitor during interspecific interactions with polar bears at the feeding site, frequently displacing polar bears approximately 50 percent of the time. Conversely, female polar bears with cubs displayed more frequent aggression regardless of whether the interaction was intra or interspecific (Miller et al. 2015).

On May 15, 2008, the polar bear was listed under the ESA as a threatened species throughout its range due to loss of sea ice habitat caused by climate change (Federal Register 2008). As a result of the ESA listing, the polar bear was also listed as a depleted species under the MMPA. Polar bears in the southern Beaufort Sea have declined from an estimated 1,500 bears in 2006 to about 900 in 2010, and the SBS population is designated as a strategic stock. Population estimates in 2015 have stayed steady around 900 bears in the SBS (ADF&G 2018a).

In 2010, USFWS designated critical habitat for the polar bear through a formal rulemaking process. The designation was set aside in 2013 as a result of legal challenges by the State of Alaska and other groups. That ruling was reversed in 2016 and the original designation has been reinstated. In accordance with section 4(f) of the ESA, USFWS issued the final Polar Bear Conservation Management Plan on December 20, 2016 (USFWS 2016a). The Plan was developed as a practical guide to implementation of polar bear conservation policies in the United States. The purpose of the Plan is to articulate the conditions whereby polar bears would no longer need the protections of the ESA. The Plan contains a set of fundamental goals reflecting shared values of diverse stakeholders. The goals focus on conservation of polar bears while recognizing values associated with subsistence take, human safety, and economic activity (USFWS 2016a).

ii. Whales

Bowhead Whale

Bowhead whales are found only in Arctic waters of the Northern Hemisphere where they are often associated with pack ice in shallow waters. For management purposes, four stocks of bowhead whales have been recognized worldwide by the International Whaling Commission and occur in the Sea of Okhotsk and the offshore waters of the Spitsbergen, western Greenland in Hudson Bay and Foxe Basin, eastern Canada in Baffin Bay, and Davis Strait. The Western Arctic stock, also known as the Bering, Chukchi-Beaufort stock, or the Bering stock is the only stock found in Alaska, and is adjacent to the Sale Area (Muto et al. 2016).

Bowhead whales spend their entire lives in far northern waters, and unlike other baleen whales, they do not migrate to temperate or tropical waters to calve. Most of the western Arctic stock spend December to March in wintering areas in the northern Bering Sea. In the spring, from April through May, they follow fractures in the ice, moving north and east, through the Chukchi Sea to the eastern Beaufort Sea (Citta et al. 2015). Mating bowhead whales have been observed from March to August, but mating is believed to occur primarily in March. After a gestation period of about 13 months, most bowheads give birth in May, although calves may be born from March through July. (Muto et al. 2016).

By mid-summer, they are found in the ice-free waters of the southeastern Beaufort Sea and west Amundsen Gulf. In August and early September, large numbers of subadults are sometimes seen feeding in shallow waters along the north coast of the Yukon. Bowhead whales are also occasionally seen around Utqiagvik in the summer, indicating that there may be important summer feeding grounds in that area. Bowheads have also been spotted far offshore in the eastern part of the Alaskan Beaufort Sea in August. In the fall from September through December, bowhead whales return to the Bering Sea to overwinter (Citta et al. 2015; George et al. 2015; Muto et al. 2016).

Bowhead whales usually travel alone or in small groups of up to six whales. They may be found in larger concentrations on feeding grounds. Many factors contribute to the timing and path of bowhead whale migrations and their use of feeding areas. These include oceanographic characteristics, ice pack movements, wind-driven ocean currents, and upwellings (George et al. 2015).

Bowhead whales filter their food through long baleen plates. A single bowhead needs an estimated 100 metric tons of krill annually, consisting of copepods, amphipods, euphausiids, and other small crustaceans. Bowheads feed at all depths from the surface to the bottom, and sometimes bring mud to the surface. Bowheads concentrate for feeding at places and depths of zooplankton concentrations. Copepods are important food for bowheads which undergo annual cycles that vary by location and may be influenced by timing of ice breakup in the spring (Citta et al. 2015). Transient killer whales are the only known predators of bowhead whales. In a study of marks on bowheads taken in the subsistence harvest, 4.1 to 7.9 percent had scars indicating that they had survived attacks by killer whales (Muto et al. 2016).

Bowhead whales feed seasonally in response to food abundance, though much of the bulk of their annual food intake occurs between fall and early spring. Research documenting the stomach contents of harvested bowhead whales found stomachs contained less food during spring (Muto et al. 2016 citing Quakenbush et al. 2010). Studies have also found that bowhead whale stomachs generally contain food in the fall. Bowhead whales feed regularly in the nearshore waters of the eastern, central, and western Beaufort Sea during September through October as they make their fall migration. Some studies have indicated that most of the annual food requirement of adults and subadults is obtained from the Bering and Chukchi seas, and that only a minority of their food comes from the eastern and central Beaufort Seas (Citta et al. 2015).

Based on concurrent passive acoustic and ice-based visual surveys, one study reports that the Western Arctic stock of bowhead whales increased at a rate of 3.7 percent from 1978 to 2011, during which time abundance tripled from approximately 5,000 to approximately 16,000 whales (Muto et al. 2016 citing Givesn et al. 2013). Another study estimated the yearly growth rate to be 3.2 percent by using a sight and resight analysis of aerial photographs from 10 years (1984–1994, plus 2003) (Schweder et al. 2009).

Bowhead whales likely hear in low frequency ranges, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Subsistence hunters note that bowhead whales are sensitive to noise during the spring whaling season, and based upon bowhead vocalizations, it is suggested that they would be most sensitive to frequencies ranging 20 Hz to 5kHz, with maximum sensitivity ranging 100–500 Hz (Erbe 2002). Additionally, olfaction may also be important to bowhead whales. Recent research on the olfactory bulb and olfactory receptor genes suggests not only that bowheads not only have a sense of smell, but that it may be better developed than in humans. Researchers suggest that bowheads may use their sense of smell to find dense prey aggregations (Thewissen et al. 2011).

Bowhead whales were originally listed as an endangered species in 1970 under the Endangered Species Conservation Act. In 1973, they were listed as endangered under the ESA, and are considered depleted under the MMPA (NOAA 2018a). In 2000, the NMFS issued a 90-day finding on a petition to designate critical habitat for the Western Arctic stock of bowhead whales. In 2002, the NMFS ruled to not designate critical habitat for the Western Arctic stock of bowhead whales. Generally, when a species is listed as endangered under the ESA, critical habitat is also designated, but because the bowhead whale was listed before 1978, designating critical habitat is discretionary (Federal Register 2002).

Beluga

Beluga whales are a medium sized cetacean, approximately 11–15 feet in length, and are related to narwhals, sperm whales, killer whales, dolphins, and porpoises. Beluga whales are easily distinguished from other whales by their white coloring and lack of a dorsal fin. The beluga whale is a toothed whale, but unlike other toothed whales, beluga neck vertebrae do not fuse, allowing for flexibility of the head and neck. Calves are dark gray when born and grow progressively lighter with age, until they are pure white at approximately age 14 for females and 18 for males (Muto et al. 2016).

Beluga whale populations are distributed throughout the seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere. Five beluga whale stocks are recognized within U.S. waters (Muto et al. 2016): Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and Beaufort Sea. Depending on the season and region, beluga whales may be found in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea, eastern Chukchi Sea, and the Mackenzie Delta (Muto et al. 2016 citing Hazard 1988). Data from satellite transmitters on whales from the Beaufort Sea, Chukchi, and Eastern Bering Sea stocks show that beluga whales from these summering areas are overwintering in the Bering Sea, and some stocks may use separate wintering locations. Belugas found in Bristol Bay and the northern Gulf of Alaska and Cook Inlet remain in those areas throughout the year. Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Muto et al. 2016 citing Shelden 1994 and Quakenbush 2003).

The general distribution pattern for beluga whales shows significant seasonal changes. During the winter, the Beaufort Sea stock may winter in more nearshore waters of the Northern Bering Sea. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt, give birth, and care for their calves (Muto et al. 2016 citing Finley 1982 and Suydam 2009). Annual migrations can be more than thousands of miles. In aerial surveys conducted between 1982 and 2009, belugas were observed mainly as individuals and in small groups of two or three, except during July when belugas gathered in the warm, shallow waters of the Mackenzie River estuary and were observed in large clumps of 100 or more animals (Duval 1993; Harwood et al. 1996; Harwood and Kingsley 2013).

Movement patterns between July and September vary by age or sex classes. Adult males frequent deeper waters of the Beaufort Sea and Arctic Ocean, where they remain throughout the summer. All the belugas that moved into the Arctic Ocean were adult males that traveled through 90 percent pack ice cover to reach the higher latitudes by late July through early August. Females, both adult and immature, remained mostly near the Beaufort and Chukchi seas shelf break. Immature males moved farther north than immature females but not as far north as adult males. All of the belugas frequented water with depths exceeding 600 feet along and beyond the continental shelf break (Citta et al. 2013; Stafford et al. 2016).

Sources used to estimate abundance for belugas in the waters of northern Alaska and western Canada have included both opportunistic and systematic observations. Abundance estimates reported in 1993 of 21,000 belugas for the Beaufort Sea stock were similar to that reported in 1985 (Muto et al. 2016 citing Duval 1993 and Seaman et al. 1985). The most recent aerial survey was conducted in July 1992, and resulted in an initial estimate of 19,629 beluga whales in the eastern Beaufort Sea (Muto et al. 2016 citing Harwood 1996). To account for availability bias, researchers recommended a correction factor, which was not data based, resulting in an adjusted population estimate of 39,258 animals (Duval 1993). Generally, survey data more than eight years old was not used to calculate minimum population estimates due to a decline in confidence in the reliability of an age abundance estimate. In this case, however, trend data from 2013 indicating the stock was at least stable or increasing supported the estimates based on the 1992 survey resulting in a minimum population estimate of 32,453 whales in 2015. There is no data to suggest the stock is declining (Harwood and Kingsley 2013; Muto et al. 2016).

iii. Seals

Ringed Seal

Ringed seals are the smallest and most abundant of the Arctic ice seals. The ringed seal was chosen as the sentinel species for monitoring contaminants in the Arctic because it is the most abundant Arctic pinniped, has a circumpolar distribution, plays an important role in the Arctic marine food web, and is an important part of the Inuit diet (Harwood et al. 2015; Harwood; Smith; et al. 2012; Jones et al. 2014; Muto et al. 2016). There are currently five recognized subspecies of the ringed seal with the Alaska stock considered the portion for the *Phoca hispida* occurring in the US Beaufort, Chukchi, and Bering Seas. However, thorough examination of the evidence for separate breeding populations has not been completed and taxonomic status of Arctic species remains undetermined (Muto et al. 2016 citing Berta and Churchill 2012).

Ringed seals spend much of the summer and early fall in the water feeding. Ringed seals eat a variety of invertebrates and fish, typically feeding on a variety of fish, amphipods, euphausiids, mysids, shrimp, bivalves and cephalopods (Kelly et al. 2010). The particular species eaten depends on availability, depth of water, distance from shore, and some studies have shown diet variability due to age, sex, and season (Ferguson et al. 2017). In Alaska waters, important food species are arctic cod, saffron cod, shrimps, and other crustaceans (Kelly et al. 2010).

Females give birth to a single, white-coated pup in snow dens on either land-fast or drifting pack ice during March and April. Female seals build lairs in pressure ridges or under snowdrifts for protection from predators and severe weather. There is some evidence that females lacking maternal experience give birth in drifting pack ice and may be more subject to polar bear predation. More experienced females give birth in land-fast ice and may have higher reproductive success (Muto et al. 2016).

Activities of ringed seals on the ice vary with the seasons. During May and June, ringed seals use the ice as a solid surface on which to haul out and complete their annual molt. During this time, they spend long periods hauled out on the ice basking in the sun. It is thought that warmer skin temperatures cause the new hair to grow more quickly. Feeding is greatly reduced during the molt. When hauled out on the ice, ringed seals are very wary. They are usually found near cracks, open leads, or holes where they have rapid access to water if they detect a human or predator approaching (Harwood; Smith; et al. 2012; Harwood; Thomas; et al. 2012; Muto et al. 2016).

The amount of time spent on the ice increases as the molt season progresses. In summer, as the nearshore ice melts, most of the adult ringed seals are found along the edge of the pack ice, seaward of the Sale Area. Subadults may remain in the ice-free areas. Open leads and cracks in the ice are used to surface and breathe, and are kept open as freeze-up begins (Harwood; Smith; et al. 2012). During winter and spring, most of the breeding adults are found on stable land-fast ice. From March through May, during the spring breeding and pupping season, high densities of adults remain in the land-fast ice while subadults are most numerous in adjacent flow ice zones (Muto et al. 2016).

The population assessments of ringed seals in the Beaufort and Chukchi Seas mostly have been confined to the U.S. and Canadian waters. In 1970, the number of ringed seals visible on shorefast ice along the North Slope of Alaska between Point Lay and Kaktovik was estimated to be at least 11,612 (Kelly et al. 2010 citing Burns and Harbo 1972). Estimates have also been derived for all

Alaskan shorefast ice habitats in both the Chukchi and Beaufort Seas based on aerial surveys in 1985 to 1987. The estimates were 250,000 ringed seals in the shorefast ice and 1–1.5 million ringed seals in Alaskan waters, including seals in the shorefast ice habitat (Kelly et al. 2010 citing Frost 1985). Aerial surveys conducted in the eastern Beaufort and Amundsen Gulf regions of Canada in 1981 to 1982 estimated the number of ringed seals on ice in the eastern Beaufort at between 5,400 and 5,500 respectively (Kelly et al. 2010 citing Kingsley and Lunn 1983).

Population estimates released in the mid-1980s were a product of accumulated data from aerial surveys between 1970 and 1976 extrapolated to the entire Beaufort Sea and estimated 40,000 ringed seals for the winter and spring months and 80,000 for the summer months. The summer estimate was based on an assumption the population would double as seals migrated from the west and south (Frost et al. 2004). The population estimates for ringed seals in 1999 and 2000 of 252,488 and 208,857 respectively, were derived from both survey results from aerial surveys conducted along the Chukchi Sea coast and a model of time out of the water developed from satellite data loggers deployed on six seals in Kotzebue Sound and Prudhoe Bay (Bengtson et al. 2005). The most recent population estimate of at least 300,000 ringed seals for the Chukchi and Beaufort seas was released in 2010 and is based on estimates from surveys in the late 1990s and 2000 (Bengtson et al. 2005; Frost et al. 2004; Kelly et al. 2010). Researchers state this is likely an underestimate since the Beaufort surveys were limited to within 25 miles of shore, the surveys covered only a portion of the range, and the data is more than eight years old. As these surveys represent only a fraction of the stock's range and occurred more than a decade ago, current and reliable data on trends in population abundance for the Alaska stock of ringed seals are considered unavailable as of 2016 (Kelly et al. 2010; Muto et al. 2016). However, the Final Rule promulgated by the NFMS listing the Arctic subspecies of ringed seal threatened, it is stated there are millions of Arctic ringed seals and are widely distributed and genetically diverse (77 Fed. Reg. 76,706-38 (Dec. 28, 2012)).

On December 28, 2012, the NMFS listed several subspecies of ringed seals, including the Arctic subspecies and thus the Alaska stock of ringed seals, as threatened under the ESA due to concerns of sea-ice cover (Federal Register 2012a). Because of its threatened status under the ESA, this stock was designated as depleted under the MMPA. As a result, the stock was classified as a strategic stock. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of Arctic ringed seals under the ESA. The decision vacated the NMFS' listing of the Arctic ringed seals as a threatened species, and subsequently, Arctic ringed seals are no longer designated as depleted or classified as a strategic stock (Alaska Oil & Gas Assciation et al. v. National Marine Fisheries Service et al. 2016). On May 3, 2016, the NMFS appealed the decision of the District Court to the US Court of Appeals for the Ninth Circuit. The appeal is currently pending.

Bearded Seal

Bearded seals are a boreoarctic species with a circumpolar distribution whose range extends from the Arctic Ocean south to Sakhalin Island in the Pacific, and south to Hudson Bay in the Atlantic. There are two recognized subspecies, *E.b. barbatus*, which inhabits the Atlantic sector including the Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay, and *E. b. nauticus*, which inhabits the Pacific sector which includes the remaining portions of the Arctic Ocean and the Bering and Okhotsk seas (Muto et al. 2016 citing Ognev 1935, Scheffer 1958, Manning 1974, and Heptner et al. 1976). Although the geographic distributions of these subspecies are not separated by obvious gaps and distinct boundaries do not appear to exist in the actual populations, *E. b. nauticus* was further divided into an Okhotsk Distinct Population Segment (DPS) and a Beringia DPS based on evidence for discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk (Cameron et al. 2010; Muto et al. 2016 citing Burns 1981, Kelly 1988, and Rice 1998). Only the Beringia DPS is found in U.S. waters, and is considered the Alaska stock (Muto et al. 2016). Aerial and acoustic surveys have documented the year-round presence of bearded seals in the Beaufort Sea and off the coast of the Sale Area (Muto et al. 2016; Jones et al. 2014; MacIntyre et al. 2013).

Distribution and seasonal movements are closely associated with seasonal changes in sea ice. Bearded seals can be found in a broad range of ice types, particularly during the critical life history periods when they haul out to give birth, nurse pups, rest, and molt. Bearded seals prefer ice in constant motion, with natural openings and areas of open water, such as leads, fractures, and polynyas for breathing, hauling out on the ice, and access to water for foraging (Bengtson et al. 2005). Bearded seals in the Beaufort Sea were most abundant where drifting pack ice interacts with fast ice, creating leads and other openings (Jones et al. 2014). When bearded seals are on the ice, they are readily recognized by their large size and their habit of resting singly at the edge of floes, oriented toward the water (Bengtson et al. 2005).

The region that includes the Bering and Chukchi seas is the largest area of continuous habitat for bearded seals (Muto et al. 2016). The Bering and Chukchi seas are generally covered by sea ice in late winter and spring and are then mostly ice free in late summer and fall, a process that helps to drive a seasonal pattern in the movements and distribution of bearded seals in this area (Bengtson et al. 2005 citing Burns 1981). During winter, most bearded seals in Alaska waters are found in the Bering Sea, while smaller numbers of year-round residents remain in the Beaufort and Chukchi seas, mostly around lead systems and polynyas (Jones et al. 2014; MacIntyre et al. 2013). Bearded seals are widely distributed during late winter and early spring in the broken, drifting pack ice from the Chukchi Sea to the ice front in the Bering Sea. From mid-April to June, as the ice recedes, many bearded seals that overwinter in the Bering Sea migrate northward through the Bering Strait into the Chukchi and Beaufort seas where they spend the summer and early fall at the southern edge of the Chukchi and Beaufort sea pack ice at the wide, fragmented margins of multiyear ice (Cameron et al. 2010).

Bearded seals are the largest of all Arctic seals, and are easily distinguished by their unpatterned gray to brown coat, small head in proportion to their body size, long whiskers, and square-shaped foreflippers. Adults can grow to seven to eight feet in length, from the nose to the tip of the tail, and weigh 575 to 800 pounds, with females weighing slightly more than males. Bearded seals weigh the most in the winter and early spring when they have a thick layer of blubber under their skin. The blubber serves as insulation and as an energy source during the breeding and pupping season. Bearded seals lose weight during the reproductive and molting seasons when they do not forage much (ADF&G 2016b).

Female bearded seals give birth to a single pup on top of the ice in late April or early May. Females become sexually mature at about five or six years of age, and males at about six or seven years of age. Bearded seal pups are born with a soft grayish-brown natal coat called lanugo that insulates them until they can build fat reserves. Lanugo is shed about one month after birth when the adult pelage is grown. Pups rapidly increase their weight to around 190 pounds during a nursing period that may last one month. Most of the weight gained is blubber. Females nurse pups for about one month before weaning takes place during ice breakup. Most bearded seals breed in late May or early June just after weaning their pups (Cameron et al. 2010).

Bearded seals feed primarily on benthic organisms, which are more numerous in shallow water where light can reach the seafloor. As such, the bearded seals' effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters where they can reach the ocean floor to forage (Cameron et al. 2010 citing Kosygin 1971, Heptner et al. 1976, Nelson et al. 1984, Fedoseev 2000, Kovacs 2002). Bearded seals generally associate with seasonal sea ice over shallow water of less than 656 feet, but in the Beaufort Sea, bearded seals prefer areas of open ice cover and water depths of 82 to 246 feet (Cameron et al. 2010 citing Stirling et al. 1982). Bearded seals are considered to be foraging generalists because they have a diverse diet with a large variety of prey items throughout their range and can switch their diet to include schooling pelagic fishes when useful (Dehn et al. 2007). Some aspects of bearded seal diet are the same in different geographical locations, although the species may differ slightly. The variability is likely a result of differences in prey assemblages in each location. Major prey for bearded seals in the Beaufort Sea include spider crabs, octopus, echiurids, shrimp, clams, Arctic cod, saffron cod, smelts, and herring (Cameron et al. 2010; Dehn et al. 2007). Foraging by bearded seals is believed to integrate vision and tactile senses since they can see in almost total darkness and can track moving prey from more than 100 feet away using their whiskers (MacIntyre et al. 2013).

As of 2016, a reliable population estimate for the Beringia DPS was not available, but research programs have recently developed new survey methods and partial, but useful, abundance estimates (Muto et al. 2016). In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). Although a complete analysis of data from these image-based surveys has not yet been published, using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012 resulted in an abundance estimate of approximately 299,174 bearded seals in those waters (Conn et al. 2014). In 2010, the population of the Beringia DPS was estimated to be about 155,000 bearded seals, based on extrapolation of existing aerial survey data that considered the current population of bearded seals in the U.S. waters of the Bering Sea to be about double the 63,200 estimate, corrected for seals in the water, or approximately 125,000 individuals (Cameron et al. 2010 citing Ver Hoef et al. 2010). Additionally, Cameron et al. (2010) derived crude population estimates that were not corrected for seals in the water for the Beaufort Sea of 3,150 bearded seals, extrapolated from aerial surveys conducted between 1974 and 1979. This is likely a substantial underestimate given the known subsistence harvest of bearded seals in this region. Also included are approximately 27,000 seals for the Chukchi Sea based on extrapolation from limited aerial surveys flown along the Chukchi Sea coastal regions from Shishmaref to Utqiaġvik during May to June 1999 and 2000 (Cameron et al. 2010 citing Stirling et al. 1982; Bengtson et al. 2005). The average density of bearded seals was 0.18 seals per square mile in 1999 and 0.36 seals per square mile in 2000. Highest densities were along the coast south of Kivalina (Bengtson et al. 2005).

The life histories of bearded seals are linked to seasonal changes in ice conditions. Any extreme variation in their sea ice habitat may have a considerable effect on the persistence of the population (Cameron et al. 2010; Muto et al. 2016). Stemming from concerns regarding the ongoing and projected loss of sea-ice cover, the NMFS listed the Beringia and Okhotsk DPS as threatened under the ESA on December 28, 2012 (Federal Register 2012b). Because of its threatened status under the ESA, both the DPS were designated as depleted under the MMPA and classified as a strategic stock. On July 25, 2015, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of the Beringia DPS under the ESA. The decision vacated the NMFS' listing of the Beringia DPS of bearded seals as a threatened species. Consequently, the Beringia DPS was no longer designated as depleted or classified as strategic under the MMPA. On October 24, 2016, the U.S. Court of Appeals for the Ninth Circuit reversed the judgment of the District Court, reinstating the ESA listing (Alaska Oil and Gas Association et al. v. Pritzker et al. 2016; Muto et al. 2016). On May 12, 2017, the District Court entered final judgment reinstating the threatened listing for the Beringia DPS of bearded seals under the ESA. On January 22, 2018, the U.S. Supreme Court rejected requests to review protections for the bearded seals by Alaska Native organizations and industry associations.

Spotted Seal

Spotted seals are distributed along the continental shelf of the Bering, Chukchi, and Beaufort seas, and the Sea of Okhotsk south to the western Sea of Japan and northern Yellow Sea. Spotted seals can be found along the continental shelf of the Beaufort Sea in summer, and are commonly seen in coastal waters of northern Alaska during ice-free seasons (Muto et al. 2016). The name is descriptive of its markings, consisting of numerous dark, irregularly shaped spots on a lighter background, usually of brownish yellow color. Spots are most numerous on the back and upper flanks (Boveng et al. 2009). Spotted seals are divided into three DPSs based on genetics, geography, and breeding groups: the Bering DPS, the Okhotsk DPS, and the Southern DPS (Boveng et al. 2009). The Bering DPS is considered the Alaska stock of the spotted seal (Muto et al. 2016).

Spotted seals are migratory and extremely mobile. The distribution of spotted seals is seasonally related to specific life history events that can be broadly divided into two periods: late-fall through spring when whelping, nursing, breeding, and molting occur in association with the presence of sea ice for hauling out, and summer through fall when seasonal sea ice has melted and most spotted seals use land for hauling out (Boveng et al. 2009). During spring, they tend to prefer small floes, and inhabit mainly the southern margin of the ice in areas where water depth does not exceed 650 feet, and move to coastal habitats after molting and the retreat of the sea ice. In summer and fall, spotted seals use coastal haul-out sites regularly, and may be found north in the Chukchi and Beaufort Seas (Muto et al. 2016). Spotted seals enter the Sale Area in July and are known to haul out on the outer islands of the eastern Colville River delta (SAExploration 2015). Spotted seals move out of the Beaufort Sea from September to mid-October as the shorefast ice reforms (Muto et al. 2016). The Beaufort Sea represents peripheral summer range for this species (SAExploration 2015). Historically, 400 to 600 seals annually inhabited the Colville and Sagavanirktok River deltas, but recently only about 20 seals have been observed at any one site (SAExploration 2015 citing Johnson et al. 1999).

The annual timing of reproduction coincides with the period of maximum sea ice extent. Spotted seals are annual breeders. Whelping generally occurs between late March and the end of April and breeding occurs from late April to mid-May. Males and females become sexually mature around four to five years old. Pups weigh 15.4 to 26.5 pounds at birth. Pupping occurs anytime from early April to the first part of May, although the peak is during the first two weeks of April. Spotted seal pups are born with a wooly white coat called lanugo and retain it for two to four weeks after birth. Pups are nursed for three to four weeks, during which time they more than double in weight. Pups are dependent on the sea ice and rarely enter the water while nursing, and early break up of ice can lead to high levels of pup mortality. Weaning occurs abruptly when the mother abandons the pup. Adult females mate about the same time their pups are weaned (Boveng et al. 2009).

Spotted seals eat a varied diet including crustaceans and cephalopods from continental shelf and shelf break waters, but their principal prey is schooling fish (Dehn et al. 2007). There are geographical and seasonal difference in their prey. Spotted seals in the Colville River delta are likely associated with summer whitefish and salmon spawning runs, which suggests an ecological affinity to the river system more than to the ocean, although they are regularly observed in marine waters a few miles offshore (SAExploration 2015 citing Green et al. 2007; BOEM 2014). Along the coast, spotted seals feed on herring, capelin, saffron cod, some salmon, and smelt. Arctic cod were consumed more often by spotted seals in the Bering Sea than in the Chukchi Sea, and saffron cod was more common in stomachs of harvested seals taken in the Chukchi Sea than in the Bering Sea (Quakenbush et al. 2009). Spotted seals tend to feed more pelagically than benthically (Dehn et al. 2007).

Recent surveys and analyses have substantially improved the documentation of the spotted seal population breeding in the U.S. waters of the Bering Sea. In spring of 2007, a large segment of the breeding area was surveyed by helicopter from an icebreaker, and the abundance of spotted seals was estimated using a model that incorporated variation due to detectability, availability (proportion hauled out), and changes in extent and concentration of sea ice during the surveys. The model estimate of abundance was 233,700 spotted seals (Ver Hoef et al. 2014). A more extensive fixed-wing aerial survey that encompassed most the spotted seal breeding area was conducted during April to May of 2012 and 2013. Using a portion of the data collected from 10 broadly-distributed survey flights during April 2012, researchers calculated the mean population estimate to be 460,268 spotted seals (Conn et al. 2014). The method accounted for uncertainty in detection rate and species classification, as well as availability. Previous surveys and estimates for spotted seals in the Bering Sea are problematic to interpret and to compare with recent estimates because there is insufficient information available to assess detection rates, species misclassification rates, area surveyed, extrapolation to unsurveyed areas, and other critical factors for estimating abundance and trends (Conn et al. 2014; Ver Hoef et al. 2014; Muto et al. 2016 citing Braham et al. 1984; Fedoseev et al. 1988; Fedoseev 2000; Rugh et al. 1995).

In response to a petition to list the spotted seal as threatened or endangered under the ESA from concerns over impacts of habitat loss due to climate change, the NMFS conducted a status review of the species. The NMFS determined that only the Southern DPS is likely to become endangered throughout all or a significant portion of its range in the foreseeable future and should be listed as threatened (Boveng et al. 2009). Spotted seals in Alaska are not designated as depleted under the MMPA or listed as threatened or endangered under the ESA. The Alaska stock of spotted seals is not considered a strategic stock, and no other threats are thought to pose significant demographic risks to the Bering DPS (Muto et al. 2016).

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Chapter Five: Current and Projected Uses in the Lease Sale Area

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Figures

Chapter Five: Current and Projected Uses in the Lease Sale Area

This chapter considers and discusses the current and projected uses in the Sale Area, including uses and value of fish and wildlife as required by AS 38.05.035(g))(1)(B)(iv). The land and waters included in and near the Sale Area provide habitat for a variety of fish, birds, terrestrial and marine mammals, as described in Chapter Four. The Sale Area also supports a variety of uses such as subsistence, sport, and limited commercial harvest activities. The Sale Area and surrounding lands are used to a limited extent for recreation and tourism. The primary industrial use of the Sale Area is for oil and gas development. The following information is not intended to be all inclusive, but to provide an overview of the current and projected uses of the Sale Area.

A. Subsistence

Several studies have been performed regarding the current and traditional areas used for subsistence activities and harvests in recent years. Iñupiat people have lived on the North Slope for approximately 12,000 years according to the archaeological record. As recently as the end of the nineteenth century, they lived a seminomadic lifestyle setting up temporary settlements located in proximity to the seasonal resources (MMS 2009). Iñupiat culture is characterized by strong kinship ties, cooperative efforts, and sharing. Iñupiat who maintain a close relationship to the land and perpetuate an understanding of the seasons and animals by educating youth are highly respected. Land and the natural environment are primary and sacred in the Iñupiat world view. Names and songs identify the land and Iñupiat see man's place in the universe as a member of the world. The Iñupiat view, being a part of the environment rather than apart from it, resulting in a subsistence life of complete dependence on the near environment, weather, and living resources (NSB 1979). For a thorough compilation of subsistence baseline information for the Sale Area, see MMS (2009); Pederson (1985); Hoffman (1988); MMS (1990, 1995); Jacobson (1982); NSB (1979). For attention to social and cultural impacts, see MMS (1995); NSB (2015c, 2015b, 1979).

1. Subsistence Values

The fish, birds, mammals, and plants of the Sale Area have been used by the residents of North Slope communities and villages for thousands of years, forming the resource base for fishing, hunting, and gathering activities that are integral to the history, culture, food security, and economy of the area. The primary use of these resources is for subsistence, which broadly refers to "any harvest of use of fish, wildlife, and wild plants for home use. It also incorporates the noncommercial exchange or sharing of resources…" (NSB 2015a).

Management of fish and wildlife in the Sale Area can fall under the authority of either the state or federal government, and may be subject to international treaties or agreements. Management authorities and types of harvest activities may overlap. Sport and subsistence hunting and fishing on state lands are managed by the Alaska Department of Fish and Game (ADF&G). The ADF&G compiles and analyzes harvest and biological information, enabling the establishment of ecologically sound and population-based fishing, hunting, and trapping regulations. This information may also be used to promote conservation strategies and recovery actions for wildlife on state lands.

Subsistence hunting and fishing on federal lands and waters, including waters adjacent to federal lands, are managed by the Federal Subsistence Management Program. Federal management of marine resources falls under the jurisdiction of either the National Marine Fisheries Service or the U. S. Fish and Wildlife Service, depending on the species. The International Whaling Commission manages whaling activity. North Slope residents serve on a number of advisory committees such as the North Slope Borough (NSB) Fish and Game Management Committee and co-management organizations such as the Alaska Eskimo Whaling Commission and the Alaska Migratory Bird Co-Management Council, which provide input to state and federal management agencies. Additionally, the NSB Wildlife Department works with state and federal agencies facilitate sustainable harvests and assure participation by NSB resident in management of wildlife resources.

2. Subsistence Fishing, Hunting, and Gathering

State and federal subsistence fishing and hunting occur in and around the Sale Area. Alaska law defines subsistence as “noncommercial, customary, and traditional uses” of fish or game for a variety of purposes. Pursuant to AS 16.05.258, subsistence uses must be consistent with sustained yield and subsistence users must be provided reasonable opportunity to harvest fish and game resources first. However, in the sense that Alaska Native people predominately use the term “subsistence” contrasts in important, although different, ways from both current federal and state legal definitions. Alaska Native people distinguish subsistence uses of hunting, fishing, and gathering activities that have ties to the culture, history, and traditions of the region from those activities that are commercial in nature (Raymond-Yakoubian et al. 2017).

Under Title 19 of the North Slope Borough Municipal Code (NSBMC), subsistence is defined as “an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (NSBMC 19.20.020(67)). The Alaska National Interest Lands Conservation Act (ANILCA) defines subsistence usage as “the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade” 16 U.S.C. § 3113.

Seasons on the Arctic coast are marked by the arrival and departure of sea ice, river ice, and changing winds. After the breakup of river ice and the retreat of fast ice along the shoreline, the tundra thaws and mobility is mostly restricted to open waterways and established trails. Seasons are also marked by the arrival and departure of migrating caribou, waterfowl, and bowhead whale. In the summer, the primary modes of transportation are by small skiff (14–18 feet), which can navigate the shallow channels of the river deltas and lagoons and by all-terrain vehicle (ATV) for overland access. In winter, snowmachines and, to a lesser degree, dogsled teams provide transportation to hunting and fishing camps. Subsistence activities may require rural residents to travel to seasonal hunting and fishing areas and camps offshore and inland to the Brooks Range (BLM 2013).

Subsistence activities in and around the Sale Area occur onshore and offshore. Birds, fish, marine mammals, land mammals, and plants are all sources of subsistence food and supplies. Wildlife harvested may consist of caribou, moose, sheep, waterfowl, whales, walrus, and seals. Plant resources such as berries, roots, and wood harvests are also important. Subsistence harvest uses include furs and hide for clothing; wood and other fuels for heating and cooking; wood and other natural materials for construction, making household goods, trade goods, ceremonial uses, and arts and crafts (NSB 2015a). Bowhead whales, beluga whales, several species of seals, and caribou still provide the bulk of subsistence needs for local communities (NRC 2003; Trammell et al. 2015).

Subsistence species tend to be migratory and seasonally abundant. Successful hunts require knowing when and where to intercept these resources as they migrate. For species that migrate through the Sale Area over a relatively short period, adverse weather conditions or equipment problems may reduce or inhibit harvest activities or lead to the inability to harvest at all. Most harvest activities tend to be concentrated near communities, along rivers, and along the coastline as accessibility is an important factor (NSB 2015a).

Based on a 2000 study prepared for the Alaska Department of Environmental Conservation by ADF&G, rural residents in Arctic Alaska harvest about 10,507,255 pounds of wild food annually, or 516 pounds per person. Harvest levels vary broadly between communities and most subsistence resources are shared, traded, given to others, or sold on a limited basis.

To support subsistence, technology, such as boats, ATVs, fuel, and gear is necessary and purchased with cash (ADEC 2000). These non-subsistence goods purchased with wages are also shared. More recent statistics are available on a community based level from ADF&G. Below is a table that shows the household costs of subsistence activities in the North Slope communities.

Table 5.1.—Average Household Cost of Subsistence Activities 2010 & 2015.

Village Subsistence Costs	2010			2015		
	Average Household Costs	Sum	Number Surveyed	Average Household Costs	Sum	Number Surveyed
Anaktuvuk Pass	$3,175	$165,119	52	$6,435	$379,650	59
Atqasuk	$3,960	$174,250	44	$4,425	$208,030	49
Utqiaġvik	$3,762	$2,554,319	679	$5,312	$1,721,262	324
Kaktovik	$4,315	$202,800	47	$3,512	$137,100	39
Nuiqsut	$7,135	$492,366	69	$6,144	$393,200	64
Pt. Hope	$5,477	$750,280	137	$9,106	$137,100	98
Pt. Lay	$8,042	$265,400	33	$5,333	$213,325	40
Wainwright	$6,752	$695,410	109	$3,769	$399,555	106

Source: (NSB 2015a)

To ensure subsistence is protected, the locations of harvest areas and sites, and the harvest and participation levels (demand for resources), must be identified. Also, it is essential and legally mandated that healthy populations of fish and wildlife be conserved. When it is necessary to restrict the taking of fish and wildlife, subsistence uses are given priority over all other consumptive uses. Federal and state laws regulate subsistence use, access, and the trading of subsistence resources. On federal lands, the federal government is required by Title VIII of ANILCA to provide a subsistence priority for rural Alaska residents unless the state provides this priority through its laws. AS 16.05.258 regulates subsistence use and allocation of fish and game. Subsistence uses in Alaska are regulated by the US Fish and Wildlife Service, Office of Subsistence Management, and the ADF&G, Division of Subsistence. For a discussion of the foreseeable effects of a proposed oil and gas lease sale on subsistence uses, see Chapter Eight.

The Iñupiat people are generally divided into two distinct groups based on their subsistence uses. The Nunamiut group live more inland and focus their subsistence harvest on caribou. The Taġiugmiut group primarily subsist on marine mammals and fish including seals and whales (MMS 2009). Each community in the sale area conducts subsistence harvest, with the majority occurring in the vicinity of Utqiaġvik, and a large percentage of the subsistence harvests occur near Nuiqsut, Kaktovik, and offshore in the barrier islands north of Prudhoe Bay. Approximately half of subsistence hunting trips are within a day's journey from the hunter's community, but half of those hunting trips involve overnight or longer duration in search of the resource (MMS 2010).

Figure 5.1 depicts the travel corridors and locations of subsistence hunting from participants in a Global Positioning System (GPS) aided study of the locations and patterns of subsistence hunters from villages on the North Slope. Using the communities' Inupiaq names, the map displays the tracks taken by select subsistence hunters from the communities of Point Lay (Kali), Wainwright (Ulġuniq), Utqiaġvik, Atqasuk, Nuiqsut, and Anaktuvak Pass in both winter (with shorefast pack ice), and summer or ice-free seasons (Harcharek 2015). Figure 5.2 depicts subsistence use areas and sites in and around the Sale Area including traditional locations for harvest of several subsistence species.

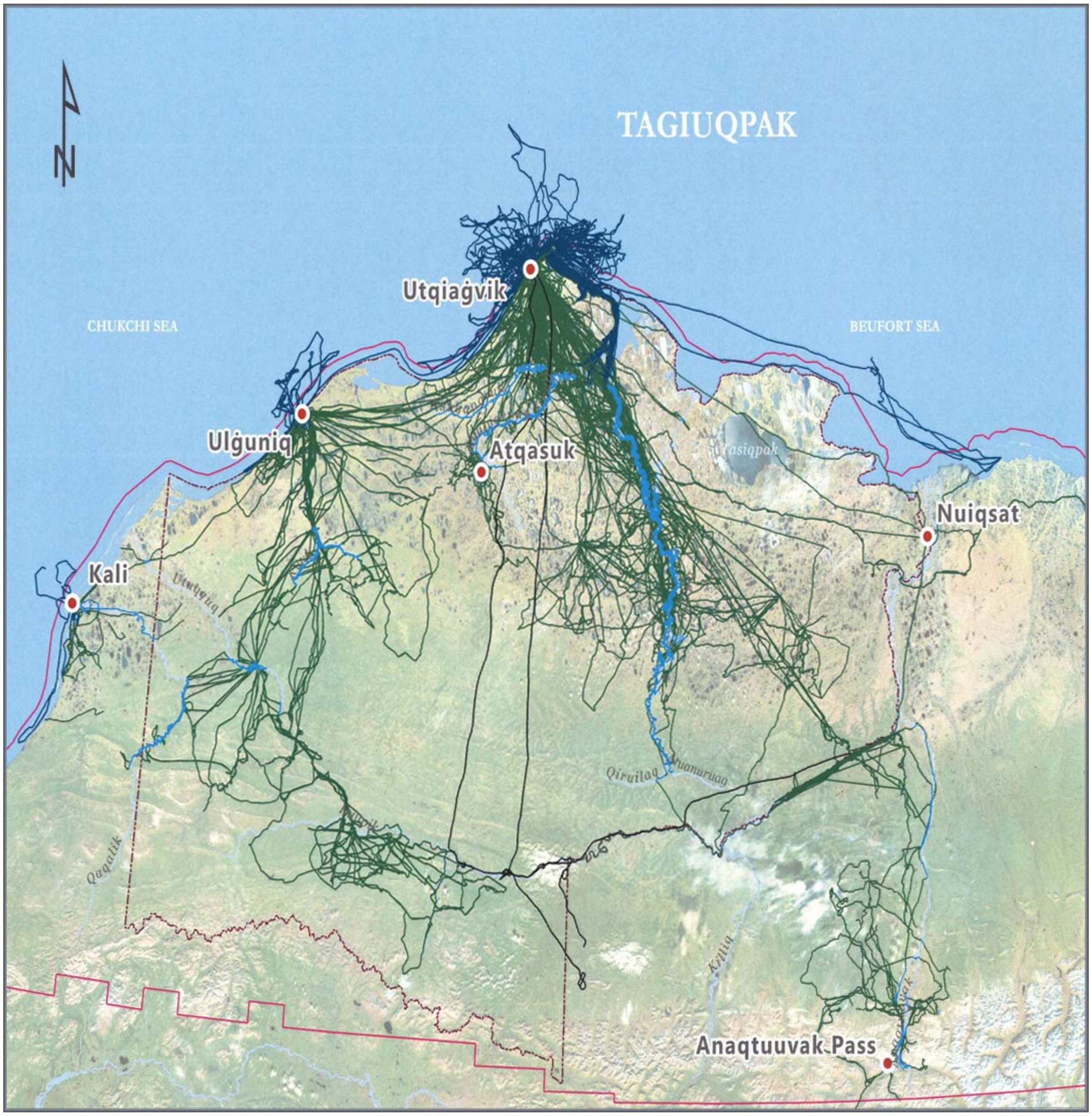
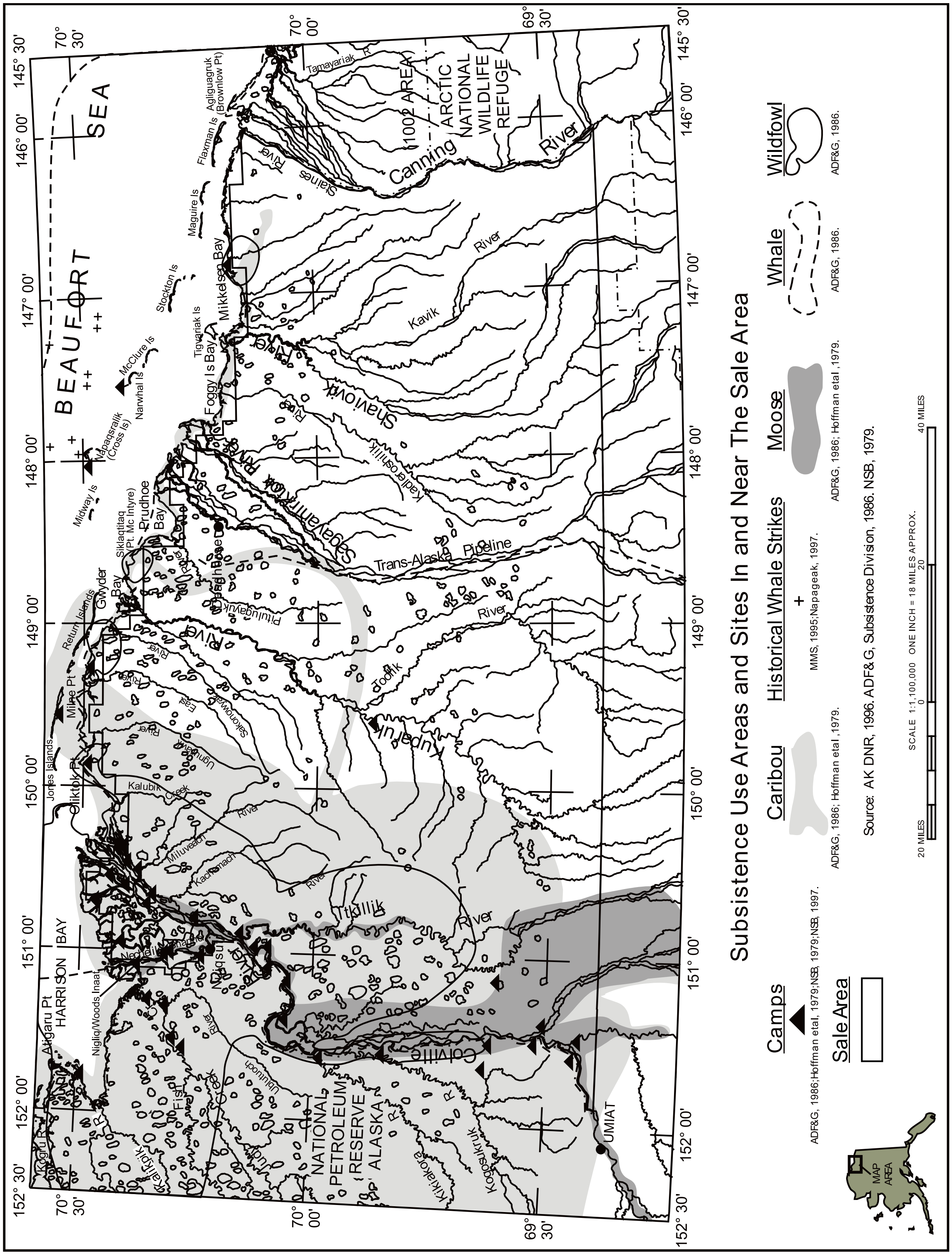


Figure 5.1.—Subsistence Harvest GPS Tracks

Source: (Harcharek 2015)

Figure 5.2.—Subsistence Use Areas and Sites in and Near the Sale Area



a. Utqiaġvik

The most recent published ADF&G subsistence harvest data for the Utqiaġvik area is from 2014. Approximately 89.2 percent of the Utqiaġvik residents used food from subsistence harvests of all types of resources in 2014. They harvested an estimated 1.9 million pounds of resources or approximately 362 pounds per person. This data is based on a sampling of 259 surveyed households. Fish are a vital source of food for subsistence users in Utqiaġvik and used by approximately 80 percent of the residents. Approximately 253,311 pounds of fish were harvested for subsistence use in Utqiaġvik in 2014 including 165,905 pounds of whitefish, 57,262 pounds of salmon, 11,172 pounds of grayling, and 7,148 pounds of smelt (ADF&G 2017b).

Over 70 percent of the Utqiaġvik residents use caribou for subsistence and they harvested an estimated 4,322 caribou or 587,897 pounds of caribou meat in 2014. Marine mammals were used by over 71 percent of the Utqiaġvik residents with an estimated harvest of over one million pounds of meat. This meat was comprised of 570,426 pounds of whale meat and 340,089 pounds of seal meat. Additionally, approximately 6.6% of the residents reported using polar bear for subsistence, and three polar bear were harvested in 2014 for a total of 1,116 pounds of polar bear meat (ADF&G 2017b). The walrus harvest by the residents of Utqiaġvik fluctuates between years depending on the abundance and dispersal of this species. Utqiaġvik is the northeastern edge of the Pacific walrus' range and harvest is typically restricted to late July and August (Bacon et al. 2011).

Over 50,000 pounds of bird meat and eggs were harvested by Utqiaġvik residents in 2014. Various types of vegetation were used for subsistence purposes by 43 percent of the Utqiaġvik residents in 2014 including berries, mushrooms, and wild greens. Approximately 2,975 pounds of vegetation were harvested for subsistence in 2014 (ADF&G 2017b).

b. Anaktuvuk Pass

In 2014, 98.1 percent of the residents of Anaktuvuk Pass utilized food from subsistence harvests of all types of resources. They harvested an estimated total of 124,269 pounds of resources which relates to approximately 391 pounds per person. This data is based on a sampling of 53 surveyed households. Approximately 91 percent of Anaktuvuk Pass residents used some species of fish as a subsistence resource. Approximately 10,448 pounds of fish were harvested for subsistence use in Anaktuvuk Pass in 2014 including 7,618 pounds of char, 2,518 pounds of grayling, and 226 pounds of salmon (ADF&G 2017b).

Over 88 percent of the Anaktuvuk Pass residents reported using caribou for subsistence and they harvested an estimated 56,032 pounds of caribou meat in 2014 (ADF&G 2017b). Dall sheep, wolves and moose are also important subsistence resources for the residents of Anaktuvuk Pass (Bacon et al. 2011). Marine mammals were used by over 62 percent of the Anaktuvuk Pass residents however, none of the surveyed residents reported harvest of any marine mammals (ADF&G 2017b). The residents of Anaktuvuk Pass traditionally do not rely on marine resources as heavily as other villages on the North Slope. Most of the people in the village receive marine resources from coastal villages, and some of the residents travel to coastal villages to hunt and harvest marine mammals (Bacon et al. 2011). Various types of vegetation were used for subsistence purposes by 69.8 percent of the Anaktuvuk Pass residents in 2014 including berries, mushrooms, and wild greens. Approximately 1,676 pounds of vegetation was harvested for subsistence in 2014 (ADF&G 2017b).

c. Kaktovik

The ADF&G maintains a Community Subsistence Information System, and there is limited data available for Kaktovik. The most recent data was collected from 2002 concerns resident subsistence fishing. In 2002, approximately 40 percent of the Kaktovik residents used subsistence fish resources including Dolly Varden, lake trout, and cisco. According to the survey results, approximately 2,649 pounds of Dolly Varden, 200 pounds of lake trout, and 2,187 pounds of cisco were harvested (ADF&G 2017b).

In 2010, a team of University of Fairbanks researchers studied the subsistence practices of Kaktovik residents. The interviews from the study noted annual Bowhead and beluga harvests in the community. In 2009, the study showed three Bowheads harvested and over 18,000 pounds of beluga whales (UAF 2014). Terrestrial mammals are also harvested including caribou, fox, Dall sheep, wolves, and wolverine, but caribou and Dall sheep were the most important subsistence food resources. The residents reported harvesting 112 caribou and 18 Dall sheep. Waterfowl harvest makes up a significant percentage of the subsistence diet in Kaktovik. The residents harvested 277 brant and 149 white fronted geese in the 2003 survey. Additionally, the residents of Kaktovik reported harvesting berries, roots, rhubarb, salmon berries, and sour dock in the late summer months of 2003 (Bacon et al. 2011). Kaktovik residents harvest caribou generally following calving season in the late summer. In recent years, the harvest by the residents of Arctic Village occurs mainly in the winter months when the herd congregates near that community (Caikoski 2015).

d. Nuiqsut

All Nuiqsut residents use food from subsistence harvests, and over 89 percent of the residents participated in the harvest of all types of resources in 2014. They harvested an estimated total of 371,991 pounds of resources or approximately 896 pounds per person. This data is based on a sampling of 58 surveyed households. Fish are a vital source of food for subsistence users in Nuiqsut and used by approximately 97 percent of the residents. Approximately 88,995 pounds of fish were harvested for subsistence use in Nuiqsut in 2014 including 78,608 pounds of whitefish, 41,740 pounds of cisco, 3,889 pounds of salmon, 2,250 pounds of char, 1,626 pounds of grayling, and 913 pounds of smelt (ADF&G 2017b).

Approximately 90 percent of the Nuiqsut residents use caribou for subsistence and they harvested an estimated 774 caribou making up approximately 105,193 pounds of caribou meat in 2014. Nuiqsut residents also harvested 12 moose for subsistence in 2014 resulting in 6,581 pounds of moose meat. Marine mammals were used by over 71 percent of the Nuiqsut residents with an estimated harvest of over 169,366 pounds of meat. This meat was comprised of 148,087 pounds of whale meat and 21,279 pounds of seal meat (ADF&G 2017b).

Nuiqsut whaling crews travel to Cross Island which serves as the base camp for fall whale hunts, which is about 73 miles northeast of the village. It is also a common practice for some hunters from Nuiqsut to mobilize to Utqiaġvik to join in spring bowhead hunt (Bacon et al. 2011). Whalers from Nuiqsut travel up to 109 miles to Cross Island where they set up a camp to hunt whales, which is approximately 17 miles north of Prudhoe Bay. In 2015, four crews from Nuiqsut whaled from the base camp at Cross Island which is less than in recent years. Over the 19-day season, three bowhead whales were harvested. This was not the full quota allowed for 2015, but the whalers cited the rough weather and poor visibility, not other vessel traffic as the reasons for not filling the quota (Galginaitis 2016).

Over 4,857 pounds of bird meat and eggs were harvested by Nuiqsut residents in 2014. Various types of vegetation were used for subsistence purposes by 67 percent of the Nuiqsut residents in 2014 including berries, mushrooms, and wild greens. Approximately 414 pounds of vegetation was harvested for subsistence, of which over 400 pounds was from berries (ADF&G 2017b).

B. Commercial and Sport Fishing

1. Commercial Fishing

In the entire NSB, five residents held commercial fishing permits in 2015 and four residents held commercial fishing permits in 2016 for inland fish species (CFEC 2017). There has been a moratorium on commercial fishing in the Beaufort Sea since August 2009. ADF&G breaks down fishery management units and the Sale Area is located within the Arctic District. In the Arctic District, a commercial fishery has existed in the recent past in the Colville River delta. Commercial fishing typically takes place during late June and July for broad and humpback whitefish and October through early December for Arctic and least cisco. Since 1990 commercial fishing efforts have mainly occurred in October and November for Arctic and least cisco. Set gillnets are used, and fishing during fall months is conducted under the ice. The fish not sold to a processor were used for subsistence purposes. No commercial harvest has been reported since 2007 from the Colville River (Menard et al. 2017).

2. Sport Fishing

To simplify the management of Alaska's resources, ADF&G's Division of Sport Fish divides the state into three major regions, each broken down into individual management areas. The North Slope Management Area is part of the larger Interior Region Management Area. The North Slope of the Brooks Range subarea includes all waters north of the Brooks Range flowing into the Beaufort and Chukchi seas from Point Hope on the west to the Canadian border on the east including adjacent saltwater area. Major drainages in this area include the Colville, Sagavanirktok, Canning, and Kuparuk rivers. These drainages provide rearing, spawning, and winter habitat for diadromous Beaufort Sea Dolly Varden. Alaska's third largest lake, Teshekpuk Lake, along with hundreds of smaller lakes are located on the coastal plain. Most of these lakes are inaccessible by road and too shallow to support fish populations, but there are dozens of lakes that contain lake trout, Arctic char, Arctic grayling, and burbot. These populations are generally slow-growing and can only support minimal harvest. Sport anglers on the North Slope commonly fish for Chinook salmon, chum salmon, Arctic char, Dolly Varden, lake trout, Arctic grayling, sheefish, Northern pike, and burbot (ADF&G 2017d).

Sport fish harvest surveys are collected by ADF&G and the results are published as estimates. A minimum of 12 responses to the survey is required for ADF&G to publish estimates for statistical purposes. The ADF&G estimates that 50 anglers fished offshore in 2016 in the North Slope region within Survey Area Z which encompasses areas outside of the Sale Area. Those anglers fished approximately 220 days and harvested 36 pink salmon and 140 Chinook salmon. In 2015, 28 anglers fished for an estimated 217 angler days but reported no successful harvested fish (ADF&G 2017a).

Based on the same 2016 survey data, an estimated 489 anglers reported fishing along the Dalton Highway and fished approximately 1,503 angler days. They reported harvesting 355 Dolly Varden and 211 grayling. In the Sagavanirktok River, an estimated 427 anglers fished approximately 1,468 days and harvested 147 Dolly Varden and 142 grayling. In other streams and lakes in the region, an estimated 315 people fished approximately 1,081 angler days and reported harvesting 97 Dolly Varden and 104 grayling (ADF&G 2017a).

There is limited additional data available on sport fishing within the Sale Area. In the North Slope subarea, sport fishing is generally light but variable. The average effort for the years 2009 through 2013 was 3,861 angler-days, with more than 64 percent coming from Haul Road fisheries. In 2014, sport fishing effort was 3,641 angler-days with almost 43 percent coming from Haul Road fisheries (Scanlon 2015).Along the Dalton Highway, people fish in Happy Valley Creek just south of the Sale Area boundary for Burbot and Dolly Varden during August and September. Arctic grayling inhabit the Kuparuk River and its tributaries. The Sagavanirktok River parallels the Dalton Highway and is easily accessible for fishing within the Sale Area. Arctic grayling and Dolly Varden inhabit the river, but the Dolly Varden leave the river for the ocean in the summer months. They return to the river in the end of August. The Sagavanirktok River is most commonly fished where the highway comes close to it for easy access (ADF&G 2003).

C. Hunting and Trapping

All hunting of big and small game in the onshore portion of the Sale Area is managed by ADF&G. In Alaska, all residents that hunt are considered subsistence hunters because they are required to salvage the meat. The state is divided into 26 game management units (GMUs). All Arctic Ocean drainages between Cape Lisburne and the Alaska-Canada border are contained in GMUs 26A, 26B, and 26C. Unit 26A lies west of the Itkillik River drainage, and west of the east bank of the Colville River between the mouth of the Itkillik River and the Arctic Ocean. A significant portion on Unit 26A overlaps with the NPR-A. Unit 26B extends from the eastern boundary of 26A to the west bank of the Canning River, and the west bank of the Marsh Fork of the Canning River and the Sale Area is contained within GMU 26B.

Guided and unguided sport hunting occurs near coastal communities, as well as on state and federal lands. Hunting seasons and guidelines are determined by the Alaska Board of Game and administered by ADF&G. The Alaska Department of Fish and Game permits hunting, trapping, and fishing on the North Slope in Game Management Units 26 and 23, with certain restrictions. The Dalton Highway Corridor Management Area is located within GMU 26B and extends five miles from each side of the Dalton Highway north of the Yukon River. The Dalton Highway corridor is closed to hunting for big and small game, except with bow and arrow, and use of motorized vehicles is restricted in the corridor. Firearms possession by industry employees is restricted. All of Unit 26C is within the Arctic National Wildlife Refuge. It is unknown exactly how many animals of each species are harvested within the Sale Area in any given year (ADF&G 2017c). Below is a map depicting the boundaries of GMU 26 on the North Slope.

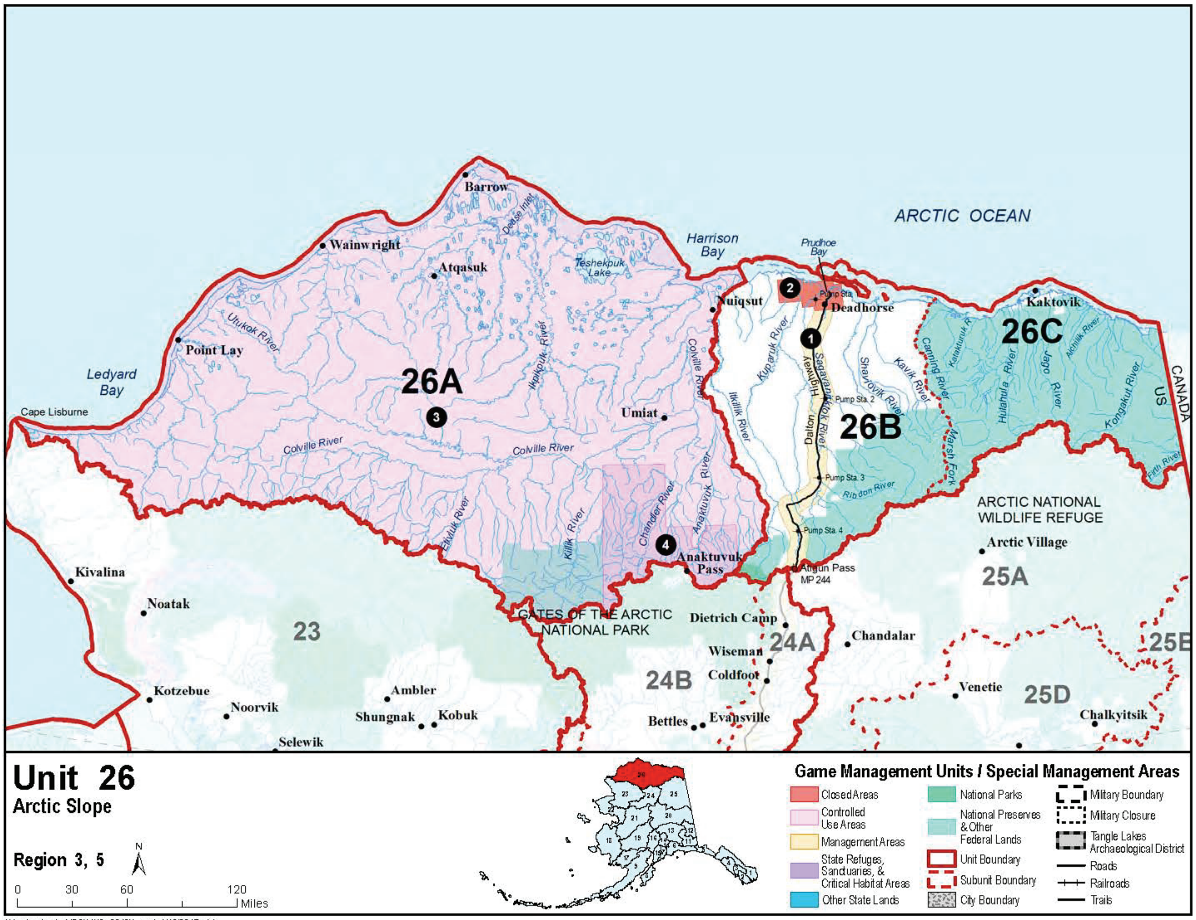


Figure 5.3.—GMU 26 Boundaries

Source: (ADF&G 2017c)

Hunting statistics collected by ADF&G are not specific to the Sale Area, but estimate the harvest of whole GMUs. Statistics on hunter residency, success rate, mode of transportation, and whether commercial services were used are also collected. (ADF&G 2006).

1. Brown bear

The most recent published population estimate in GMU 26B was 265 brown bears. Only 20 permits are issued each year in a drawing. The resident open season is from August 25 through December 31. With a registration permit, a resident can take one bear each regulatory year between January 1 and May 31. In GMU 26B, 18 brown bears were taken in 2012 and 22 were taken in 2013. Additionally, three male bears were taken by ADF&G staff for predator control in 2012 and two male bears were taken in defense of life and property in 2013 (Lenart 2015a). Generally speaking, non-residents and residents are able to harvest one bear each regulatory year in Unit 26 with non-residents required to be accompanied by a guide.

Most of the harvests of brown bear in GMU 26B occurred in the Sagavanirktok, Ivishak, and Ribdon rivers. In GMU 26C, 16 brown bears were taken in 2012 and 29 bears were taken in 2013. The majority of the harvested brown bears were taken by Alaska residents ranging between 50 percent and 91 percent of those successful hunts in 2012–2013 and typically the brown bears were normally taken in conjunction with a caribou hunt (Lenart 2015a).

2. Caribou

The reporting for hunting of caribou in GMU 26B in the Sale Area is focused on the Central Arctic caribou herd (CAH). Reporting on the Western Arctic caribou herd (WAH) is from GMU 26A, and reporting on the Porcupine caribou herd (PCH) falls primarily within GMU 26C. Hunting seasons and limits change often in GMU 26.

For the CAH in 2012, 1,430 hunters, 1,126 of which were Alaska residents, reported that they hunted for caribou in GMU 26B and 26C. They reported harvesting 1,007 caribou from the CAH and a 50 percent success rate. In 2013, 1,423 hunters, 983 of which were Alaska residents, participated in caribou hunting and harvested 854 caribou from the CAH with a 43 percent success rate. Nonresidents took 23 percent of the harvested caribou in 2012 and 38 percent of the caribou in 2013. Approximately 25 percent of the hunters reporting harvest in GMU 26B were bowhunters. Over 50 percent of the hunters harvested caribou from the CAH in the month of August and approximately 25 percent of the harvest occurred in September (Lenart 2015b).

The WAH's range covers northwestern Alaska and they inhabit the western portions of the Sale Area. In total, approximately 13,352 caribou from the WAH were harvested in 2012 and 12,713 were harvested in 2013. Approximately 95 percent of the total harvest has been by people that live within the traditional range of the WAH. Residents of the communities in the herd's range harvest the animals year-round based on the availability of the herd. Recent data shows a decline in the population of the WAH. Therefore, in 2014 and 2015, ADF&G conducted a public outreach campaign in the communities near the Sale Area to inform people of the population status of the herd and discussed options to reduce the harvest (Dau 2015).

The PCH seasonally inhabits portions of the Sale Area, though the data on the harvests are from GMU 26C which is in the Alaska National Wildlife Refuge to the east of the Sale Area. The total annual harvest of the PCH is not known because the reporting from this region is infrequent or inconsistent. However, it was estimated that in 2012 between 1,821 and 2,121 caribou were harvested. In 2013, an estimated 3,456 to 3,756 caribou were taken from the herd. Nonlocal Alaskan hunters and nonresidents reported harvesting 138 caribou in 2012 and 136 caribou in 2013 from GMU 26C which are assumed to be from the PCH (Caikoski 2015).

3. Moose

Access plays a dominate role in the chronology of the moose harvest. Most moose are harvested during the first 10 weeks of the regular hunting season, when lack of snow makes it feasible to access hunting grounds with highway vehicles or boats. Alaska hunting regulations show no open season for moose in Units 26B and 26C with Unit 26A with a limited open season for the 2017–18 season.

Based on the results of the most recent moose species management report from ADF&G, hunters in GMU 26B reported their harvests between 2006 through 2012, which was open in April. Unfortunately, most of the reported hunting was illegal because it took place in September when the moose hunting season was closed. The first legal moose was reported harvested in April 2010. Success rates for moose hunters ranged between 25 and 69 percent. Most of the successful hunters in GMU 26B and 26C were Alaska residents from outside the North Slope area. In 2012, 20 permits were issued and 11 moose were harvested, and in 2013, 12 permits were issued and 2 moose were harvested in GMU 26B (Lenart 2012).

4. Muskoxen

Muskoxen populations in Alaska declined substantially in Unit 26B beginning in 1999. In 1998, ADF&G determined that a harvest of no more than 20 muskoxen was necessary to provide a reasonable opportunity for subsistence use. In all of Unit 26B, reported harvest of muskoxen was nine, three, and eight, respectively in 2002, 2003, and 2004. In 2004 and 2005, there were eight muskoxen taken in Unit 26. Restrictions in regulations ensure a low harvest. Some hunters may not have reported their harvests, despite the permit systems. There have not been any permits issued for muskoxen since 2006; however, in March 2011, there were three muskoxen illegally harvested in GMU 26A (Lenart 2015c). There is not an open season for muskoxen in Unit 26 from July 1, 2017 to June 30, 2018.

5. Trapping

Trapping of furbearers takes place in and around the Sale Area. Only four percent of those with a license to trap responded to the ADF&G Alaska trapper questionnaire in 2016, but of those that did, 36 people reported trapping within Region V which encompasses the Sale Area. Of the respondents from Region V, the participants spent approximately eight weeks trapping in 2016. Trappers in Region V had the longest average trap line of any region in the state with approximately 27 miles per trap line. In Region V, red fox was the most important animal according to the trapper survey followed by wolverine, river otter, wolf, and marten. Based on the sealing[4] records for the state, the trappers in Region V harvested 100 lynx, 28 river otter, 12 wolves, and 17 wolverine in 2016 (Parr 2017).

D. Tourism and Recreation

The North Slope region is remote and much of it is inaccessible by major modes of transport. Much of the region is not connected by roads, and recreational visitors either arrive by air, or use trails and rivers. Recreational activities for visitors to the region include wildlife viewing, camping, rafting, fishing, and hunting. Historically, tourism in the region has been minimal although there is increased interest in recent years. Several independent tour companies offer a variety of packages

[4] Sealing is the process of placing a marker or tag on the hide or skull by a representative of ADF&G

that include visiting specific communities like Utqiaġvik, Anaktuvuk Pass, Kaktovik, and Deadhorse, or custom planned trips to remote parts of the region.

Utqiaġvik is the largest village in the region and houses the offices for the NSB and the Arctic Slope Native Association. Additionally, the Iñupiat Heritage Center is located there. The Heritage Center's mission is to promote and perpetuate Iñupiat history, language, and culture. It also supports Iñupiat artists by providing them a place to create art or work on traditional subsistence tools, and encourages tourism in the area. It provides meeting space to host events at the heritage center, and an opportunity for the public to interact with some of the artists (NSB 2017a).

Established in 1986, the Simon Paneak Memorial Museum is located in the village of Anaktuvuk Pass. It is currently operated by the Iñupiat History, Language, and Culture department of the NSB. The main purpose of the museum is to assemble, preserve, and understand materials associated with the culture, lifestyle, and history of the Nunamiut Iñupiat people. Within the museum is the Hans Van Der Laan Brooks Range Library that houses a collection of scientific and reference material related to the region. The main focus of the museum is to depict the importance of caribou in the local people's culture and economy (NSB 2017b).

Cultural heritage tourism development, wilderness adventure travel, and ecotourism hold the greatest potential for future tourism growth within the North Slope region. Cultural and historical tourism opportunities in the NSB offer visitors unique experiences. For example, a visitor may visit a historical site such as the Cape Smythe Whaling and Trading Station in Browerville near Utqiaġvik. The station was built as a whaling station in 1893 and is the oldest frame building in the Arctic. For the more adventurous visitors, river rafting, dog mushing, backpacking, and fishing opportunities are available. The remote, natural environment of the North Slope appeals to the ecotourist who seeks an educational experience without the crowds.

Opportunities exist for the adventure traveler considering rafting, sport fishing, hunting, and other forms of outdoor recreation. The uplands provide hunting opportunities for caribou, bear, and sheep. Adventure travelers enjoy guided backpack tours and are showing an increasing interest in winter recreation activities, such as snowmachining, dog mushing, and Northern Lights viewing.

Recent information provided by the Alaska Visitor Statistics Program reported tourist visitor information for summer 2011. The survey conducted for visitor activities in the North Slope region of Alaska showed that there were 31,000 summer visitors, representing two percent of total Alaska visitors. One out of five North Slope visitors were business travelers, 23 percent were traveling for business or pleasure, 60 percent were traveling for vacation or pleasure, and 43 percent purchased a multi-day package, versus two-thirds of total visitors. The average length of stay among North Slope travelers was 13.5 nights. Eight out of 10 visitors lodged in a hotel or motel during their stay, in contrast to 38 percent of total visitors. Nearly two-thirds traveled between communities by air as compared with 11 percent of the overall market. The most popular activities were wildlife viewing, cultural activities, and hiking or nature walk, while six percent of visitors went fishing in the region. North Slope visitors reported spending an average of $1,820 in Alaska, much higher than the average Alaska visitor who reported spending $941 (McDowell 2012b).

Visitor information for fall and winter 2011 showed six percent visited the Far North, and four percent visited places outside of Nome. Three percent of visitors stayed overnight, 67 percent were traveling for business purpose, and six percent of the total international market visited the North Slope. North Slope visitors reported longest length of stay with an average of just over 19 nights, and were most likely to be repeat visitors. Visitors spent an average $1,076 in Alaska, and $550 in a community, most of which was multiday packages attributable to one community (McDowell 2012a).

E. Other Uses

1. Oil and Gas

Oil and gas exploration, development, production, and transportation have been ongoing in the Sale Area since the 1960s and 1970s. Chapter Six provides a detailed description of the history of the oil and gas industry in the Sale Area.

2. Renewable Energy

a. Wind

Across Alaska, wind energy provides over 75 percent of the utility-scale nonhydroelectric renewable energy, and over 60 megawatts of generating capacity at over 100 wind turbines. Increasing numbers of small-scale wind energy facilities, including some hybrid systems that use diesel and wind, are supplying power to rural communities (EIA 2017).

According to the North Slope Regional Energy Plan, wind resource studies have been conducted in six of the North Slope communities. The villages of Anaktuvuk Pass, Atqasuk, and Kaktovik have completed wind resource reports. Development and feasibility studies for harnessing wind power are complete for Point Hope, Point Lay, and Wainwright. Concept design reports will be conducted next followed by design and permitting activities. Communities near the coast such as Kaktovik and Wainwright experience higher winds than inland communities such as Anaktuvuk Pass or Atqasuk (WHPacific 2015).

The Alaska Energy Authority granted funds to the NSB for pre-construction phases for wind energy generation each of the North Slope villages in 2014. There are currently feasibility studies being conducted in Kaktovik, Point Hope, Point Lay, and Wainwright (AEA 2017).

b. Solar

Solar energy provides electricity in remote locations across the North Slope of Alaska and is vital for many remote project sites. Both the design of buildings to collect passive solar energy and the use of photovoltaic panels help to reduce the need for more traditional fuels. The main uses for solar energy technology is for heating buildings and hot water sources. People use systems that combine power and waste heat from electricity generation systems to heat homes and other buildings in over 70 rural Alaskan communities (EIA 2017).

The Cold Climate Housing Research Center has performed extensive work on researching the feasibility of solar energy in the extreme latitudes found in the North Slope region. The main challenge is that there are minimal solar resources available during the winter when the demand for energy is the highest, and there is an abundance of solar energy available in the summer months when the demand for energy wanes. However, the research has shown that solar power can be successful in small scale projects based on observations from several North Slope projects (CCHRC 2017).

The Alaska Center for Energy and Power conducted a case study on solar technology in remote areas in northern Alaska and examined several installations ranging in size from 2.2 to 50 kilowatts. Because of the cold temperatures and presence of snow, the system voltage is increased, electrical resistance is reduced and the reflection of light off the snow leads to higher solar radiation that can be captured by the photovoltaic cells. The case study reviewed data from many small communities in northern Alaska including Ambler, Kobuk, Nome, Galena, and Bethel among others. The study showed an offset in annual diesel use ranging from 157 gallons to 895 gallons with an average offset of over 500 gallons per system (Whitney and Pike 2017).

3. Arctic Strategic Transportation and Resource Project

The Arctic Strategic Transportation and Resources (ASTAR) project is an effort to identify and strengthen community infrastructure and facilitate access to Arctic resources. The project plans to incorporate existing Sale Area infrastructure with new potential transportation and utility corridors and shipping lanes and maritime facilities. At the community level, the project aims to lower household costs, improve public safety, and strengthen cultural exchange and community connectivity. The project also serves to make more resources, such as more coal, minerals, and oil and gas, available for use consistent with the public interest (ASTAR 2017).

The ASTAR project, as currently envisioned, would be a network of roads stretching across the Sale Area and reaching west to Point Hope while connecting communities such as Anaktuvuk Pass, Utqiaġvik, and Nuiqsut. The project is in the early planning stages with an initial budget allocated to begin gathering regional information and additional technical data across the region. With the ASTAR project in its early planning phase, the initiation of construction and completion of the infrastructure is years away. However, it is foreseeable that portions of the ASTAR project would be started and completed during the term of this finding which can be addressed by supplements to the finding (ASTAR 2017).

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Chapter Six: Petroleum Potential and the Likely Methods of Oil and Gas Transportation in the Sale Area

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Chapter Six: Likely Methods of Oil and Gas Transportation in the Sale Area

This chapter considers and discusses the petroleum potential of the Sale Area, in general terms, as well as the methods most likely to be used to transport oil or gas from the Sale Area as required by AS 38.05.035(g)(ii) and (viii). The following information is not intended to be all inclusive, but to provide a general overview.

Transporting and distributing petroleum products and natural gas from oilfields to refining and processing plants requires a comprehensive transportation system. Any oil or gas ultimately produced from leases will have to be transported to market. However, it is important to note the decision to lease oil and gas resources in Alaska does not authorize the transportation of any oil or gas. If oil or gas is found in commercial quantities and production is proposed, final decisions on transporting will be made through the local, state, and federal permitting process. No oil or gas will be transported from the Sale Area until the lessee has obtained the necessary permits and authorizations from federal, state, and local governments. The state has broad authority to withhold, restrict, or condition its approval of transportation facilities. In addition, the federal and local governments may have jurisdiction over various aspects of a given transportation alternative.

The director is required under AS 38.05.035(g)(1)(B)(viii) to consider and discuss the method or methods most likely to be used to transport oil or gas from the Sale Area, and the advantages, disadvantages and relative risks of each. Modern oil and gas transportation systems may consist of pipelines, marine terminals with offshore loading platforms, trucks, and tank vessels. The location and nature of oil or gas deposits determine the type and extent of facilities needed to develop and transport the resource. Because of the limited road system in the Sale Area and the absence of marine terminals due to shallow depths and lack of ice-free ports, the most likely method of transportation will include elevated and buried pipelines. The following discussion is a general overview of the methods most likely to be used to transport oil or gas from the Sale Area.

A. Geology

1. Tectonic and Structural Framework

Northern Alaska is made up of three distinct geologic regions: the Brooks Range, the Arctic Foothills, and the Arctic coastal plain. The Sale Area is located in the center of the Arctic coastal plain, and rock sequences with known petroleum potential underlie the entire region. The rocks under the Sale Area are exposed at the surface in the Brooks Range. Rock sequences are formed by geologic events and are often described in terms of the time period during which they were formed (Moore et al. 1994).

The Brooks Range consists of east-west trending mountain groups that reach heights of more than 6,000 feet. Rocks of pre-Mississippian age (350 million-plus years) to Paleogene age (23 million-plus years) are exposed due to extensive uplift, folding, and faulting. There is little to no oil and gas potential in the Brooks Range because of this extensive deformation and uplift, however these pre-

Mississippians to Tertiary-age rocks are studied by petroleum geologists, because they contain petroleum where they occur beneath the Sale Area.

The Arctic Foothills is a narrow province between the Brooks Range and the Arctic coastal plain, consisting of a series of rolling hills, mesas, and east-trending ridges that descend from 1,500 to 900-foot elevations. The rocks in this area are less deformed and younger than those to the south.

The Arctic coastal plain contains surface sediments formed by fluvial (moving water) and deltaic deposition. These sediments are relatively uniform sandy silts. The coastal plain is underlain by the Colville basin; a large east-west trending foreland basin of Cretaceous (135 million-plus years) to modern age. The subsurface geology of this area and the history of previous petroleum production and exploration make it the most prospective area for hydrocarbons in northern Alaska.

The history of rocks beneath the Sale Area is marked by periods of continental rifting, mountain building, and sedimentary deposition. This history is marked by four distinct geologic sequences of rocks with each having a unique sediment source area, depositional environment, and structural character. As these major rock sequences were being formed, relatively smaller-scale events, such as changes in sea level, altered the depositional environment and created additional internal complexities. The four major rock sequences from oldest to youngest (the oldest rocks are the deepest) are: the Franklinian, Ellesmerian, Rift, and the Brookian. The evolution of the area geology was:

1. A stable early Arctic continental platform before Devonian time,
2. onset of continental rifting with uplift to the north of this stable Arctic platform and deposition of sediments southward, and
3. continued rifting, uplift, and termination of deposition from the north, along with uplift of the Brooks Range and deposition of sediments from the south onto the Arctic coastal plain.

The oldest rock sequence, the Franklinian, may have once been a stable Arctic continental platform before middle Devonian time (about 400 million years ago). This sequence is also referred to as the pre-Mississippian sequence because of a lack of continuous geologic information. The Franklinian sequence contains a wide range of rock types that include volcanics, granites, carbonates, and metamorphosed argillites. Due to its geology and tectonic history, the Franklinian sequence is considered to have low petroleum potential (Moore et al. 1994).

During middle to late Devonian time, a mountain-building and rifting event uplifted the Franklinian sequence, deforming and metamorphosing the rocks in the process. Sediments from the uplifted Franklinian sequence spread southward into the large Arctic basin (epicontinental shelf). This process continued through to late Cretaceous time. These northerly-sourced sediments formed the Ellesmerian sequence (Moore et al. 1994).

The Ellesmerian sequence is the most important geologically in terms of petroleum production. Formations within the Ellesmerian sequence form the primary petroleum reservoirs at Prudhoe Bay and Endicott. The Ellesmerian sequence contains marine carbonates and quartz- and chert-rich clastic rocks, representing about 150 million years of deposition (Mississippian through Triassic). From the center of the Colville basin, the Ellesmerian thins to the south due to depositional distance from its source and thins to the north due to subsequent uplift and erosion (Moore et al. 1994).

Rifting of the continental mass dominated the geology by the end of the late Jurassic to late Cretaceous periods. The northern continental source for the Ellesmerian sediments supplied less and less sediment to the Arctic basin as time passed. Uplift and faulting of the Franklinian and Ellesmerian sequence formed fault blocks and grabens (low areas between fault blocks). These grabens were filled by sediments from the locally uplifted or upfaulted Ellesmerian and Franklinian sequences, forming the rift sequence (Moore et al. 1994). During this time, the Barrow Arch formed along the present-day Beaufort coast. Sedimentation from the north eventually ended sometime in the Late Cretaceous and the following period of non-deposition along with continued uplift along the Barrow Arch created a regional Lower Cretaceous Unconformity (LCU) which becomes angular approaching the Barrow Arch from the south. To the north of the Barrow Arch, the Ellesmerian sequence is absent. The LCU is an important migration and accumulation element for most of the oil fields on the North Slope, including Prudhoe Bay (Jamison et al. 1980).

To the south, compressional forces in the Jurassic to early Cretaceous caused thrust faulting in what is now the Brooks Range. Sediments from the thrust faulted blocks in the Brooks Range poured into the Colville basin, progressively filling it from the south, forming the Brookian sequence. Brookian sediments filled the Colville basin and spread out over the Barrow Arch and onto Alaska's continental margin during the upper Late Cretaceous through Tertiary time. Petroleum accumulations in the Brookian sequence are found throughout the North Slope basin, including at West Sak, Schrader Bluff, and Flaxman Island (Hudson et al. 2006).

Onshore present-day geology of the Sale Area is, in general, comprised of a thick section of unconsolidated Quaternary sediments, deposited within the last one million years (Figure 6.1). These sediments are probably from the Gubik Formation which unconformably overlies the weakly-cemented sediments of the upper Brookian sequence. Most Quaternary deposits are unconsolidated sand and gravel composed of reworked Brookian sediments, along with materials from the present-day Brooks Range. Overlying these deposits are ice-rich silts and sandy silts that include variable amounts of organic matter which are deposited by the numerous rivers on the North Slope. In addition to these fluvial deposits, there are local areas of eolian deposits (sand dunes) derived from river silts (Houseknecht and Bird 2006).

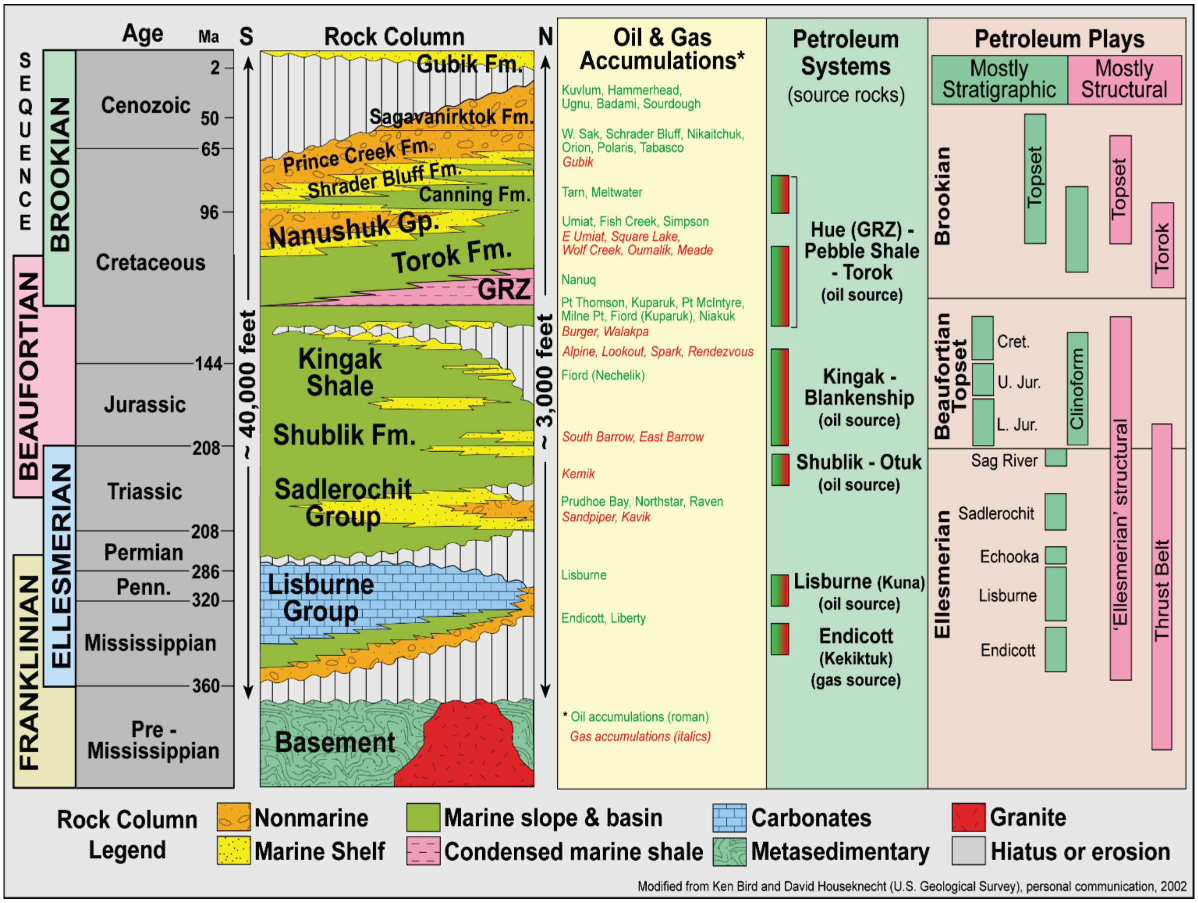

Figure 6.1.—Stratigraphic Column for Northern Alaska.

Source: DO&G, modified from Ken Bird and David Housenecht (US Geological Survey), personal communication, 2002.

B. Exploration History

Oil seeps have long been known to the Iñupiat people of the North Slope, who excavated tar-saturated tundra for use as fuel. Following reports of oil seeps along the coast by early traders, the first geologic and topographic studies were conducted in 1901. The US Geological Survey (USGS) produced the first formal descriptions of the geology of the North Slope in 1919. By 1921, prospecting permits were filed and, in 1923, President Harding created the Naval Petroleum Reserve Number 4 (NPR-4) by executive order. The USGS began analyzing the reserve by conducting reconnaissance geologic mapping from 1923 through 1926 and has continued to evaluate the region and its potential ever since.

The first exploration phase of NPR-4 ended in 1953. Between 1923 and 1953, the United States Navy drilled 37 test wells and found three oil accumulations and six gas accumulations within and adjacent to the reserve (Schindler 1988). Only two of these discoveries were considered sizable, namely Umiat, with an estimated 70 million barrels of recoverable oil, and Gubik (partly outside of the reserve), with an estimated 600 billion cubic-feet of recoverable gas. Gas from another discovery, the small South Barrow gas field, is being produced today for local consumption at Utqiaġvik.

The Bureau of Land Management (BLM) opened North Slope lands for competitive bidding in 1958 when 16,000 acres were offered near the Gubik gas field. That same year, the BLM opened four million acres in an area south and southeast of NPR-4 for simultaneous filing and subsequent drawing. From 1962 to 1964, industry exploration programs expanded rapidly. During that time, Sinclair and British Petroleum drilled a total of seven unsuccessful wildcat wells in the Arctic foothills (AOGCC 2018).

In 1964, under the Statehood Act, the State of Alaska selected and received tentative approvals from the federal government on 1.6 million acres across the northern tier of lands between the Colville and Canning rivers. In December 1964, the state held the 13th State Competitive Sale, the first on the North Slope, of leases covering 625,000 acres in the area east of the Colville River delta. In July 1965, the state held its 14th State Competitive Sale that included the onshore area near Prudhoe Bay. In the 18th State Competitive Sale held in January 1967, the offshore Prudhoe Bay tracts were offered and leased.

Following a succession of dry holes in the Arctic foothills, exploration shifted northward to the central coastal area. In 1965, the first holes drilled in the area immediately surrounding the Prudhoe Bay structure came up dry. In January 1967, a rig was moved to the Prudhoe Bay State № 1 location near the mouth of the Sagavanirktok River, culminating in the discovery of commercial oil deposits at Prudhoe Bay by Atlantic Richfield in 1968.

Following the Prudhoe Bay discovery, exploration activity increased dramatically and led to the discovery of the Kuparuk River field in 1969. Between 1967 and 1979, more than 100 exploratory wells were drilled on the North Slope (AOGCC 2018), with 23 regarded as new oil or gas discoveries. Oil production began in Prudhoe Bay with the completion of the Trans-Alaska Pipeline System on June 20, 1977.

The Organization of the Petroleum Exporting Countries oil embargo of 1973 prompted the federal government to begin a second large exploration program in NPR-4. The Naval Petroleum Reserves Production Act was signed in 1976, authorizing development of the reserve. The act transferred management of the reserve to the Secretary of the Interior and renamed it the National Petroleum Reserve-Alaska (NPR-A). Between 1974 and 1981, the USGS drilled 27 exploratory wells in the NPR-A (AOGCC 2018), but discovered no accumulations that warranted development at the time. After receiving no bids in the 1984 NPR-A lease sale, BLM did not hold another lease sale until May 1999.

Although exploration in the northeast portion of NPR-A had not produced a commercial discovery during the 1980s, most of the state land in the Colville River delta has been leased for oil and gas development since 1964. Other than exploration activity, the first major petroleum development in the delta began with the discovery of the Alpine oilfield in the winter of 1994. The initial infrastructure built two pads, with two wells, a production facility, and an airfield. Production at Alpine began in 2000, and by November, ConocoPhillips Alaska Inc. began the process to develop two satellite developments on the Colville River delta, north and south of the Alpine base.

The State of Alaska has held more than 60 North Slope oil and gas lease sales since December of 1964. During this time, 5.5 million acres have been under lease at some point, and approximately 145,000 line-miles of 2D seismic data and more than 10,000 square miles of 3D seismic data have been recorded, including onshore and offshore, state and federal acreage. In the course of exploration and development activities, over 6,900 wells have been drilled (AOGCC 2009).

C. Oil and Gas Potential

1. Overview of the Petroleum Systems Approach

The basic elements of a functional petroleum system are effective sources, reservoirs, and traps. The presence of these three elements by themselves does not ensure that a viable hydrocarbon system is present. The elements must also interact with each other properly to create oil or gas accumulations. The timing of these interactions is critical.

Source rocks contain kerogen, organic material that is predominantly composed of carbon and hydrogen, are the main ingredients in oil and gas. To form oil or gas, a source rock must be buried deep enough and long enough in an area of the basin that geochemists refer to as the “kitchen,” where the proper range of temperature and pressure converts kerogen into hydrocarbons. Generation of the oil or gas in the source rock creates excess pressure which expels hydrocarbons out of the source rock. At that point, because it is lighter than and does not mix with the water saturating the surrounding rock, hydrocarbons tend to migrate upward, either directly or along a more indirect route, following the most permeable pathways it encounters.

A reservoir rock is a porous and permeable rock (typically sandstone or a carbonate rock type such as limestone or dolomite) that can effectively store oil or gas. Less permeable rocks are sometimes suitable reservoirs for gas or lighter oil, since those fluids flow more easily than normal or heavy crude oil. An important consideration for assessing potential reservoir rocks in the North Slope are the composition and diagenesis (chemical alteration) of the volcanic rock fragments that comprise a significant percentage of framework grains in many of the sandstones in the area. Formations buried less deeply are more likely to have better preserved primary porosity.

The reservoir rock must be contained in a sealing configuration called a trap that allows hydrocarbons to migrate into the reservoir, but prevents it from escaping, thereby creating an oil or gas accumulation. Effective containment inside the trapping configuration requires an effective seal, generally a clay or mudstone layer that forms an impermeable barrier at the top of the trap that prevents hydrocarbons from escaping.

Conventional trapping configurations are generally either structural or stratigraphic. Structural traps are formed by deformation of originally flat-lying, planar strata to create either anticlines (up-warped layers) or fault-bounded compartments, forming large concave-down shapes that allow buoyant oil or gas to migrate upward and accumulate. Stratigraphic traps result when porous and permeable reservoir rock is bounded both above and to the side(s) by impermeable seal rocks, simply due to the way the different sediment types were deposited. There are also traps that are a combination of structural and stratigraphic configurations. Effective traps must be created prior to hydrocarbon generation, expulsion, and migration from the kitchen and remain intact, uncompromised by later folding, faulting, or excessive burial in order to host a productive oil or gas field (Decker 2006).

In addition to the conventional traps described above, hydrocarbon production can also occur from unconventional or "source-reservoired" traps. The terms "shale oil" and "shale gas" are used to describe this production. In this case, timely migration from the source rock to the reservoir is not necessary, since oil or gas is produced directly from the shale source rock. Source rocks have very poor permeability so reservoir stimulation by hydraulic fracturing (Decker 2011). Between 2005 and 2015, several companies acquired leases anticipating possible unconventional development. These projects are still in the early stages of evaluation.

The history of oil and gas production on the North Slope proves that all three of the critical petroleum system elements (source rocks, reservoirs, and traps) are present, effective, and have interacted with favorable timing to form commercially viable hydrocarbon accumulations.

The North Slope petroleum systems include four mega sequences, prolific source rocks, and numerous play types. Having produced more than 17 billion barrels of oil to date, the Alaska North Slope, where the Sale Area is located, contains all the essential elements of active petroleum systems (effective hydrocarbon sources, reservoirs, and traps) and offers proven hydrocarbon potential. At the individual prospect level, there is uncertainty about the timely combination of petroleum system elements to create major economic hydrocarbon accumulations, but concerted exploration can be expected to discover additional commercially viable hydrocarbon accumulations.

Oil potential is greatest along the Barrow Arch on the northern coastal plain and nearshore areas of the Beaufort Sea; gas potential is greatest farther south in the foothills and southern coastal plain. Significant additional resource potential remains to be discovered in unconventional plays, including source rock reservoirs and methane hydrate accumulations (Houseknecht et al. 2012; Collett et al. 2011). The most recent USGS assessment of undiscovered, technically-recoverable conventional resources for the central North Slope region, which corresponds roughly to the state's North Slope, Beaufort Sea, and North Slope Foothills areawide lease sales, estimates mean resources of approximately 4.5 billion barrels of oil and natural gas liquids plus approximately 37.5 trillion cubic feet of natural gas (Garrity et al. 2005). The USGS also estimates up to 2 billion barrels of potential, technically-recoverable shale oil resources between the Sale Area and areas to the west in the NPR-A (USGS 2012). In 2013, the USGS estimated there are more than 85 trillion cubic feet of undiscovered technically-recoverable natural-gas resources in gas hydrates beneath the North Slope (USGS 2013).

D. Likely Methods to Transport Oil and Gas from the Sale Area

Transporting and distributing petroleum products and natural gas from oilfields to refining and processing plants requires a comprehensive transportation system. Any oil or gas ultimately produced from leases will have to be transported to market. The director is required under AS 38.05.035(g)(1)(B)(viii) to consider and discuss the method or methods most likely to be used to transport oil or gas from the Sale Area, and the advantages, disadvantages and relative risks of each.

Strategies used to transport potential petroleum resources depend on many factors, most of which are unique to an individual discovery. The location and nature of oil or gas deposits determines the type and extent of facilities necessary to develop and transport the resource. The Alaska Department of Natural Resources (DNR) and other federal, state, and local agencies will review the specific transportation system when it is actually proposed. The following discussion is a general overview of the methods most likely to be used to transport oil or gas from the Sale Area.

Modern oil and gas transportation systems may consist of pipelines, marine terminals with offshore loading platforms, trucks, and tank vessels. A regional oil transportation system for the North Slope oil fields was established in 1977 upon completion of the Trans-Alaska Pipeline System (TAPS). TAPS is an onshore pipeline, portions of which are buried and portions of which are elevated, that is operated and monitored by the Alyeska Pipeline Service Company. The throughput capacity of TAPS plays a significant role in North Slope development. The historic maximum daily throughput capacity of TAPS was over 2.1 million barrels per day (achieved in 1988). Maximum average daily throughput as of 2000 was 990,000 barrels per day. In 2011, TAPS throughput averaged 583,000 barrels per day. The minimum throughput for viable operation has been widely debated by government and industry. According to the Alyeska Pipeline Service Company, TAPS can continue to be operated safely and with reasonably high operational confidence down to throughputs of about 350,000 barrels per day, assuming a number of issues are addressed (Alyeska Pipeline Service Company 2016).

Oil is transported about 800 miles through a 48-inch pipeline to the ice-free port of Valdez, Alaska. From the storage and marine loading terminal at Valdez, oil is loaded onto tankers and transported to the United States and foreign markets. Inadequate facilities for ocean transport near the Sale Area will likely preclude the use of marine terminals or tankers to transport oil or gas. Oil and gas produced in the Sale Area would most likely be transported by pipeline, depending on the type, size, and location of the discovery. Given the economics of transporting oil, if commercial quantities of oil are found in the Sale Area, the oil will most likely be transported through gathering lines to TAPS. Existing operations use in-field gathering lines to bring the oil from individual well sites to processing facilities for injection into TAPS and that will most likely continue into the future. Currently, there is no regional transportation system for gas that is equivalent to TAPS, but gas currently produced within the Sale Area is reinjected into reservoirs, used as fuel gas, flared, and transported within the North Slope via pipelines to other fields or villages.

Transporting oil and gas from the Sale Area is almost exclusively performed by pipeline systems. Oil is occasionally transported by truck to off-site production facilities after oil is produced from exploration well tests. No oil or gas is transported from the Sale Area via marine vessels or tankers and due to the shallow nature of the Beaufort Sea and other considerations, there is no foreseeable likelihood of oil or gas transportation via marine vessels or tankers. Existing commercial oil development on the North Slope is transferred by smaller, aboveground gathering lines that feed into TAPS. Due to the economics of oil production and development, DNR anticipates that future commercial oil discoveries will also be collected in gathering lines and transported through TAPS.

1. Pipelines or Pipeline Facility

The primary method of transporting oil in the Sale Area is by pipeline. Pipelines may be onshore or offshore. A pipeline or pipeline facility means all the facilities of a total system of pipe, whether owned or operated under a contract, agreement, or lease, used by a carrier for transportation of crude oil, natural gas, or products for delivery, for storage, or for further transportation. A pipeline is a general term that includes all the components of a total system of pipe to transport crude oil or natural gas or hydrocarbon products for delivery, storage, or further transportation. It includes all pipe, pump or compressor stations, station equipment, tanks, valves, access roads, bridges, airfields, terminals and terminal facilities, operations control center for both the upstream part of the and all other facilities used or necessary for an integral line of pipe transportation (AS 38.35.230).

Onshore pipelines may be buried or elevated as further described below. Buried pipelines are advantageous because they do not pose an obstacle to wildlife or result in scenic degradation. However, buried pipelines are more expensive to install and to maintain than unburied pipelines. This is especially true regarding inspection, repair, and maintenance. Spills may result from pipeline leaks in either buried or unburied pipelines, and leak detection systems play a primary role in reducing discharges of oil from either system.

a. Oil Transportation

Feeder pipelines, or gathering pipelines, may be connected to TAPS for oil transport. These are either elevated or buried depending on several factors such as the substance being transported, the local soil and ice conditions and other considerations such as movement of wildlife. An individual pipeline may alternate between buried and elevated, as is the case with TAPS. The advantages and disadvantages of the two options are set forth below. The mode of transport from a discovery is an important factor in determining whether or not it can be economically produced. Buried pipelines are more expensive to install and maintain than elevated pipelines. The more expensive a given transportation option, the larger a discovery will have to be for economic viability.

i. Elevated Pipelines for Oil Transport

Elevated pipelines are typically used in North Slope oil field development to prevent heat transfer from the hot oil in the pipeline to frozen soils, since heat would degrade the permafrost. The pipeline is placed on crossbeams mounted between pairs of vertical support members (VSM) (DeGeer and Nessim 2008). Above-ground pipelines can restrict caribou and other wildlife movements unless provisions are made to allow for their unimpeded passage. The current pipeline construction mitigation measures located in Chapter Nine require that pipelines be elevated seven feet except where the pipeline intersects a road, pad, or a ramp installed to facilitate wildlife passage. Additionally, the proximity of roads to pipelines may create a barrier to caribou crossing and historically it has been recommended that pipelines and roads be separated by at least 500 feet (Cronin et al. 1994). However, research suggests that may no longer be the case (Noel et al. 2004; Noel et al. 2006; Nicholson et al. 2016). The effects of roads and pipelines on caribou behavior is discussed further in Chapter Eight.

Typically, oil pipeline routes are laid out in straight-line segments (or alignments) and are installed aboveground on VSMs. On the North Slope, this installation method is preferred over buried pipelines, because aboveground pipelines take less time to construct, cause less disruption to the land during installation, are easier to monitor and repair, provide more flexibility for later modifications such as adding new pipelines than buried pipelines, and heat transfer to thaw unstable soils is minimized. Pipeline clearance is generally higher (up to 20 feet) over topographic lows (stream valleys), because engineering requirements call for a nearly level pipeline route. Small, shallow lakes could be crossed by elevated VSMs, whereas large or deep lakes would have pipeline VSMs routed around their shorelines with some setback. Pipelines crossing large rivers, such as the Colville River, could be on bridges or buried using horizontal directional drilling techniques. Elevated pipelines would likely cross narrow streams on suspension spans to minimize impacts to streambanks and riparian vegetation and to avoid potential problems associated with corrosion, maintenance, and abandonment of buried pipelines.

Elevated pipelines offer more ways to monitor the pipeline such as ground inspection, visual air inspections, ground-based infrared and airborne forward-looking infrared surveys (FLIR). In-Line Inspection can be used for both aboveground and belowground pipelines, but is the only practical method for belowground installations (SPCS 2014).

ii. Buried Pipelines for Oil Transport

Buried pipelines may be feasible in the Arctic provided that the integrity of the frozen soils is maintained. Such pipeline configurations have been used in the Milne Point Unit area. However, there are some important considerations regarding long sections of buried pipe. First is cost, which depends on length, topography, soils, and distance from the gravel mine site to the pipeline. Second, buried pipe is more difficult to monitor and maintain than elevated pipelines, although significant technological advances in leak detection systems have been made that increase the ease with which buried pipelines can be monitored. These systems are described under the oil spill prevention subsection in this chapter. Third, buried pipelines may contribute to increased loss of wetlands because of gravel fill. Finally, buried pipelines are sometimes not feasible from an engineering standpoint because of the thermal stability of fill and underlying substrate (Wen et al. 2010; DeGeer and Nessim 2008).

Advantages of Pipelines for Transporting Oil

Pipelines have been essential for gathering and transporting hydrocarbons on the North Slope since the first well was put into production. Once the Trans Alaska Pipeline System (TAPS) was completed in 1977, a critical piece of oil and gas infrastructure was in place to allow North Slope oil to be commercialized. The TAPS line still serves as one of the top ranked critical components of oil transportation infrastructure in the world (ENI 2005).

Given the lack of roads and deep-water harbor on the North Slope, pipelines have been essential to the development and commercialization of Alaska's crude oil. The only road from the rail belt of Alaska to the North Slope is the Dalton Highway, which was developed for construction of TAPS. At the time of permitting TAPS alternatives like rail or highway trucking were considered; however, given the cost of construction and comparatively low costs of operations along with the lower rate of pipeline incidents vs trucks and railcar incidents, the pipeline was selected as the most reasonable method of transportation.

The development of TAPS has allowed main transmission pipelines to be developed above ground on the North Slope to the east, west, and north. These lines serve as vital components of commercializing North Slope reserves. Without the development of the pipelines, gravel roads or gravel beds for railroads would have been used and created a patchworked and segregated landscape and more intrusive infrastructure affecting ground and wetland disturbance. Gravel roads are also more susceptible to spring flooding, are costly to construct, and need constant maintenance using more gravel materials. By comparison, once a North Slope pipeline is constructed on VSMs it requires very little maintenance since there is little or no ground disturbance. The vegetative infrastructure of wetlands and uplands retains much of its integrity and allows for much of the natural surface water to flow unimpeded.

Pipeline monitoring on the North Slope is now done mainly by using remote instrumentation, and in some cases using smart pigs and maintenance pigs. Numerous monitoring and safety systems are installed to provide redundancy in these electrical and mechanical safety systems. Additionally, mechanical shutoff valves are being replaced by vertical expansion loops to provide a more fail-safe method of controlling pipeline pressures and leaks.

iii. Disadvantages of Pipelines for Transporting Oil

The most distinct disadvantage of pipelines is their high up-front investment for construction costs. These pipeline projects on the North Slope have traditionally been built on VSMs due to the permafrost and shallow water table. This adds to the costs of pipeline development in the North Slope when compared to more temperate climates in the Lower 48.

Additional considerations for pipeline operators are the challenges of preserving the quality of crude oil along with maintenance of the pipe. The larger the pipeline, like TAPS, the more the cold weather challenges are manifested, and the more operational costs are shifted to address these issues. This is exacerbated by fluctuations in throughput. TAPS has seen as many as 2,032,928 barrels of oil in one single day in 1988 and as few as 508,446 barrels in 2015. While the daily throughput of TAPS in a year can vary depending on maintenance and season, the overall decline in throughput has introduced new challenges to the large diameter pipe such as wax build-up and potential icing in cold temperatures.

When transporting oil by pipeline, many chemicals are added to the oil to improve the rate and efficiency of throughput and to protect the pipeline. After extraction, oil cools from reservoir temperature and heavy fractions such as wax form crystals. Several deposits of wax may plug both pipelines and production facilities. To remove deposits of wax from the pipeline a vessel known as a pig is used in combination with a wax inhibitor. Other chemicals are added to the oils stream such as corrosion inhibitors to prevent corrosion damage to the pipe. Other cold-weather risks such as ice formation, reduced pigging velocities, water dropout, and reduced accuracy in leak detection can negatively impact the operation of oil pipelines and be considered a disadvantage to transporting oil by pipeline. (SPCS 2014)

iv. Tanker Vessels and Marine Terminals

Presently, tankers are not considered a method likely to be used to transport oil or gas from the Sale Area. Tankers are currently used in Alaska to transport oil to and from Cook Inlet and from the Alyeska Terminal in Valdez, the terminus of TAPS. Use of tankers brings the risk of a large oil spill, such as the 1989 Exxon Valdez spill in Prince William Sound. Shallow waters and seasonal ice in the Sale Area mean nearshore tanker transportation is not a likely method to be used to transport oil from the Sale Area.

The US Coast Guard (USCG) maintains a vessel traffic service in the Gulf of Alaska and Prince William Sound. Vessels are escorted through Prince William Sound. Two tug boats escort tankers from the Valdez terminal to Cape Hinchinbrook (Alyeska Pipeline Service Company 2011). Use of tug boats reduces the risk of a large oil spill, such as the 1989 Exxon Valdez spill in Prince William Sound.

According to the U. S. National Snow and Ice Data Center, 2017 marked the third year in a row that the annual maximum extent of Arctic sea ice hit a record low. A decline in sea ice and advances in ice-breaking ships has increased the window of navigation for the northern sea route from a four-month period between summer and autumn to the ability to sail westwards year-round and eastwards from July to December. In 2016, the northern sea route saw 19 full transits from the Atlantic to the Pacific (McGrath 2017).

b. Natural Gas Transportation

Unlike oil, gas is difficult to store due to its physical nature. Gas needs high pressures and low temperatures to increase the bulk density and needs to be transported immediately to its destination after production from a reservoir (Mokhatab et al. 2006 citing Thomas and Dawe 2003). Since North Slope gas cannot presently be transported to an off-slope market, gas produced on the North Slope is mostly used for fuel and reservoir management purposes. Produced gas in the Sale Area is typically transported within the producing field to be reinjected for reservoir pressure maintenance and enhanced oil recovery or used as fuel gas. Some pipelines transport natural gas between fields to augment operations or to local communities for heating fuel. Limited road infrastructure makes gas trucking an unlikely transportation option for gas produced from the Sale Area. Shallow Beaufort Sea waters and other complications make marine terminals and vessel transport less feasible.

The Alaska Gasline Development Corporation (AGDC) is pursuing options to bring natural gas to a market outside of the Sale Area. The Alaska Stand Alone Pipeline (ASAP) project aims to bring gas supplies to Fairbanks, Southcentral Alaska, and other communities along the pipeline route. The ASAP project proposes development of a natural gas conditioning facility in the Sale Area which could transport utility-grade gas along a 727-mile, 36-inch pipeline at a rate of 500 million standard cubic feet per day (AGDC 2014). The project is currently completing the supplemental environmental study process with construction of the project proposed to start in 2019 and completion estimated in 2023 (AGDC 2018).

A parallel, larger pipeline project is also currently being pursued by the AGDC to bring North Slope natural gas to foreign markets and local communities. The Alaska Liquid Natural Gas (Alaska LNG) project is an 800-mile pipeline system, starting in the Sale Area, to bring natural gas to local communities at select offtake points and a liquefaction plant in Nikiski for loading on marine vessels. Natural gas from the Point Thomson and Prudhoe Bay units could be transported to a gas treatment plant for shipment at a rate of 3.3 billion standard cubic feet per day along the 42-inch pipeline (LNG 2018).

Both pipeline projects are in the planning phase and are years from the initiation of construction and transport of gas from existing oil and gas fields. However, one of these major pipeline options may be completed during the 10-year term of this best interest finding. The projects can be addressed by supplements to the best interest finding.

i. Pipelines for Natural Gas Transport

Natural gas from producing regions to markets requires a transportation system. The gas may have to travel a great distance to reach its point of use. Pipelines may follow elevated or buried routes, depending upon the engineering requirements needed and the soils found in the field. Natural gas may require treatment to remove impurities and to prepare it for transport. Treatment may include depressurization and dehydration. To keep the gas flowing along the pipeline route, the gas may also undergo pressurization by compressors and liquid separation treatment.

During transport, the gas is monitored. Pigging facilities and metering stations are constructed along the pipeline to monitor and manage the gas. Central control stations manage information along the pipeline to allow for quick prevention and necessary reaction to problems (Mokhatab et al. 2006).

Currently, there are five natural gas pipelines operating in the Sale Area (SPCS 2014), but none of them transport gas away from the Sale Area. Alyeska Pipeline Service Company operates a natural gas fuel line from the North Slope fields to fuel the pump stations north of the Brooks Range (Pump Stations 1, 2, 3, and 4). The gas fuel line generally runs parallel to the mainline crude oil pipeline. The purpose of the natural gas is to fuel the pump stations for TAPS (Alyeska Pipeline Service Company 2016). Harvest Alaska, LLC, operates a 10-inch natural gas pipeline to maintain reservoir pressure which spans 16 miles between the Prudhoe Bay central compressor plant to the Northstar Island. The North Slope Borough (NSB) constructed the Nuiqsut Natural Gas Pipeline (NNGP) to transport natural gas from the Alpine production pad to the village of Nuiqsut, within the Colville River delta. The NNGP at just over 14 miles long, is above ground for almost nine miles as it leaves the Alpine Production Facility, and is buried for about 5.6 miles in tundra and under the Nechelik Channel (SPCS 2014).

Elevated and Buried Pipelines for Transporting Natural Gas

Transporting natural gas in the Sale Area is usually performed with elevated pipelines due to permafrost and ground movement. Elevated gas pipelines allow for ease of inspection, maintenance response upon leak detection, and are generally less expensive to construct. Mitigation measures require pipelines to use existing transportation corridors and be buried when geophysical conditions permit. However, when pipelines are placed above ground, pipelines must be designed and constructed to allow free movement of wildlife with elevation of the line at least seven feet above the ground (*See* Chapter Nine for mitigation measures).

Burial of natural gas pipelines can be desirable for both safety and operational reasons. High-pressure gas lines pose a risk of rupture and explosion. Burial and offset from the oil pipeline mitigate the potential impacts if a gas explosion were to occur. High-pressure gas lines operate more efficiently when chilled, and permafrost is a good material in which to install dense-phase, high pressure gas pipelines that contain natural gas liquids. In designing buried pipelines for use in the Arctic, it is important to consider large deformations that could occur from frost heave, thaw settlement, and slope movement (ASME 2008). There are only three buried natural gas pipelines in the Sale Area. A pipeline running from Pump Station 1 to Pump Station 4 is a 10-inch line which has required significant modifications to continue proper functioning due to thaw settlement and frost heave.

Advantages of Pipelines for Transporting Gas

Transportation of natural gas in the Sale Area is mainly performed through gathering lines bringing raw materials from wellheads to processing facilities and then pipelines back to well pads for reinjection into a reservoir. The incidents of accidents from transportation of natural gas via gathering lines is historically very low. Data provided by Pipeline and Hazardous Materials Safety Administration (PHMSA) shows what types of pipelines systems are most susceptible to accidents. Over the course of the period from 1992 to 2011, PHMSA data shows far fewer incidents from gathering lines than transmission and distribution lines. The data further shows the incidents of rail and trucking far exceed the incident rates of natural gas pipelines (Furchtgott-Roth 2013). Additional advantages of transporting natural gas through pipelines is the reduced cost, expanding the development of lower emission fuel, and a faster, more dependable delivery to markets.

ii. Disadvantages of Pipelines for Transporting Gas

The potential problems and risks associated with transportation of natural gas through pipelines are typically addressed in mitigation measures and lease stipulations. A major risk of transporting gas through a pipeline is a leak or explosion. The measures and methods employed to prevent leaks or explosion, including line integrity protection, pipeline monitoring, and in-line inspections, are detailed in the Spill and Leak Prevention section below. Other disadvantages related to movement of wildlife, habitat protection, subsistence access, and waterbody crossings are addressed through mitigation measures listed in Chapter Nine.

E. Spills and Releases: Risk, Prevention, and Response

The risk of a spill exists any time crude oil or petroleum products are handled. AS 38.05.035(g)(1)(B)(vii) requires the director to consider and discuss lease stipulations and mitigation measures, including any measures to prevent and mitigate releases of oil and hazardous substances, to be included in the leases, and a discussion of the protections offered by these measures. The mitigation measures related to release of oil and hazardous substances were developed after the director considered the risk of oil spills, methods for preventing spills, and techniques for responding to spills.

1. Oil Spill History and Risk

Any time crude oil or petroleum products are handled there is a risk that a spill might occur. Oil spills associated with the exploration, development, production, storage and transportation of crude oil may occur from well blowouts or pipeline or tanker accidents. Petroleum activities may generate chronic low volume spills involving fuels and other petroleum products associated with normal operation of drilling rigs, vessels, and other facilities for gathering, processing, loading, and storing of crude oil. Spills may also be associated with the transportation of refined products to provide fuel for generators, marine vessels, and other vehicles used in exploration and development activities. A worst-case oil discharge from an exploration facility, production facility, pipeline, or storage facility is restricted by the maximum tank or vessel storage capacity, or by a well's ability to produce oil. Companies do not store large volumes of crude at their facilities on the North Slope. Produced oil is processed at production facilities and transported to TAPS as quickly as possible, which reduces the possible size of a potential spill.

An analysis of oil spills on the North Slope between 1995 and 2011 found that the highest frequency of spills came from facility oil piping, process piping, and wells. The largest spills by volume generally came from flowlines. The two largest spills during the period came from storage tanks and oil transmission pipelines. The analysis found that the most frequent cause of failure leading to a spill was a valve or seal failure, and the most frequent cause of large spills (1,000 gallons or greater) was corrosion (Robertson et al. 2013). The Alaska Department of Environmental Conservation (ADEC) commonly cites the primary causes of spills as line failure, equipment failure, human error, containment overflow, and tank failure (ADEC 2016, 2015, 2014, 2013).

For fiscal years 2009 through 2016, there was an average of about 12 large spills per fiscal year in the North Slope area according to the ADEC spills database (ADEC 2017c). Nine spills were identified as significant by the ADEC during this period. Although there are risks associated with spills resulting from exploration, production, storage, and transportation of oil and gas, these risks can be mitigated through prevention and response plans such as the Unified Plan and Subarea Contingency Plans (ADEC 2010).

a. Exploration and Production

As noted above, risk factors and spill incidents within the overall oil and gas industry vary among activities. Exploration and production facilities in the Sale Area may include onshore gravel pads, drill rigs, pipelines, and facilities for gathering, processing, storing, fuel transfer, and moving oil and gas. Mitigation measure are developed to prevent and contain spills from fuel and hazardous material transfer, equipment storage, vehicle fueling, and maintenance activities. When spills occur at these facilities, they are usually related to everyday operations, such as fuel transfers. The ADEC – Spill Prevention and Response must be contacted to report a spill and begin an investigation into the cause of the spill. Reporting to the USCG, US Environmental Protection Agency (EPA), and local government contact is also required. Large spills are rare at the exploration and production stages because spill sizes are limited by production rates and by the amount of crude oil stored at the exploration or production facility.

The most dramatic form of spill can occur during a well blowout. A well blowout can take place when high pressure is encountered in the well and sufficient precautions, such as increasing the weight of the drilling mud, are not effective. The result is that oil, gas, or mud is suddenly and violently expelled from the well bore, followed by uncontrolled flow from the well. Blowout preventers, which immediately close off the open well to prevent or minimize any discharges, are required for all drilling and work-over rigs and are routinely inspected by the Alaska Oil and Gas Conservation Commission (AOGCC) to prevent such occurrences.

Blowouts are extremely rare in Alaska and their numbers decline as technology, experience, and regulations influence drilling practices. The AOGCC regulations set forth a comprehensive well permitting process and rigorous well operations inspection program. It also has a program to ensure well failures or blowouts do not occur. Drilling plans and procedures are scrutinized to assess potential problems within rock formation and the drilling fluids used to control downhole pressure. Well construction is evaluated and rigs are inspected before permission to drill is granted. Since 1949, there has only been one blowout on the North Slope that has resulted in an oil spill; however, natural gas blowouts have occurred (AOGCC 2009).

b. Pipelines

Both state and federal agencies have oversight of pipelines in Alaska. State agencies include the ADEC and the Division of Oil and Gas, which includes the State Pipeline Coordinator's Section, and the federal and state Joint Pipeline Office. Federal agencies include the PHMSA within the US Department of Transportation and the Bureau of Safety and Environmental Enforcement within the US Department of the Interior.

The pipeline system that transports North Slope crude includes flowlines, gathering lines, and pipelines that carry crude to processing facilities and to Pump Station 1, where the oil enters TAPS for transport to the Port of Valdez. Pipelines vary in size, length, and amount of oil contained. A 14-inch pipeline can store about 1,000 barrels (bbl) per mile of pipeline length. Under static conditions, if oil were lost from a five-mile stretch of this pipeline (a hypothetical distance between emergency block valves), a maximum of 5,000 bbl of oil could be discharged if the entire volume of oil in the segment drained from the pipeline.

c. Tankers

Shallow, nearshore waters and lack of ice-free ports prevent the use of tankers for transporting oil from the North Slope. Alaska's most catastrophic oil spill was the March 1989 *Exxon Valdez* tanker spill in Prince William Sound, the second largest recorded in United States waters. It spilled nearly 10.8 million gallons of crude oil, contaminated fishing gear, fish and shellfish, killed numerous marine birds and mammals, and led to the closure or disruption of many Prince William Sound, Cook Inlet, Kodiak, and Chignik fisheries (Graham 2003; Science Daily 2003; City of Valdez 2017; Alaska Office of the Governor 1989). Effects of oils spills on fish and other wildlife are discussed in Chapter Eight.

Other large tanker spills include the 1987 tanker Glacier Bay spill of 2,350 to 3,800 barrels of North Slope crude oil being transported to Cook Inlet for processing at the Nikiski Refinery (ADEC 1988). Less than 10 percent of the oil was recovered, and the spill interrupted commercial fishing activities near Kalgin Island during the peak of the sockeye salmon run.

Both incidents demonstrated that preventing catastrophic tanker spills was easier than cleaning them up, and that focused legislative attention on the prevention and cleanup of oil spills on both the federal and state levels. At the state level, statutes created the oil and hazardous substance spill response fund (AS 46.08.010), established the Spill Preparedness and Response (SPAR) Division of ADEC (AS 46.08.100), and increased financial responsibility requirements for tankers or barges carrying crude oil up to a maximum of $100 million (AS 46.04.040(c)(1)).

i. Alaska Risk Assessment of Oil and Gas Infrastructure

In May 2007, the Alaska Risk Assessment (ARA) project was launched by the ADEC. The purpose of the three-year, $5 million initiative was to evaluate Alaska's oil and gas infrastructure for its ability to operate safely. Based upon Phase I of the investigation, the project scope was revised, and the investigation changed focus to North Slope pipeline spills that resulted from loss of integrity. A North Slope Spills Analysis (NSSA) for specific North Slope pipelines was issued in November 2010, and compiled and analyzed causal information associated with the North Slope pipeline spills. The spill analysis investigated risks to oil infrastructure using available spill data, information about causal factors, and included seven specific recommendations for reducing spills from Alaska infrastructure (ADEC 2017a).

The Alaska Risk Assessment of Oil and Gas Infrastructure Oversight Report was issued and provided recommendations for future oversight activities for oil transportation (Cycla Corporation 2010). The report provided an overview of risk management and oversight systems used by other jurisdictions and provided recommendations designed to enhance risk management practices of the ADEC and strengthen risk management practice across Alaska oversight agencies (Cycla Corporation 2010). The report found that the primary job of regulators is to require practices that reinforce the operators' responsibility to ensure safe operation of their facilities; the state should not undertake a risk assessment without significant cooperation from the operators; the existing system should be refined rather than implement radical changes; and operator reporting should be expanded to improve the effectiveness of management systems (Cycla Corporation 2010).

2. Spill and Leak Prevention

Prevention and response activities begin long before any spill. Information gleaned from past spills has led to increased emphasis on prevention rather than response alone. State and federal laws require that industries that produce, store or transport oil develop contingency plans that specify measures to prevent and respond to oil spills. Contingency planning, thorough training, exercise and practice programs, improved safety standards, well-maintained equipment and routine surveillance are important components of oil spill prevention. Advancements in engineering design and equipment, redundancy in critical components, and changes in operating procedures and practices have contributed to improvements in well control (AOGCC 2009).

If oil or gas is found in commercial quantities and production is proposed, final decisions on transportation will be made by the lessees and be evaluated though the local, state, and federal application and permitting processes. Those processes will consider any required changes in oil spill contingency planning and other environmental safeguards and will involve public participation.

a. Blowout Prevention

Oil, gas, and other hazardous substances may be released in a well blowout. A well blowout can take place when high pressure gas is encountered in the well and sufficient precautions, such as increasing the weight of the drilling mud, are not effective. The result is that gas or mud is suddenly and violently expelled from the well bore, followed by uncontrolled flow from the well. Blowout preventers, which immediately close off the open well to prevent or minimize any discharges, are required for all drilling and workover rigs and are routinely inspected by the AOGCC (AS 46.04.030). Blowout preventers greatly reduce the risk of a gas release. If a release occurs; however, the released gas will dissipate unless it is ignited by a spark (Florence et al. 2011).

Each well has a blowout prevention program that is developed before the well is drilled. Operators review bottom-hole pressure data from existing wells in the area and seismic data to learn what pressures might be expected in the well. Engineers use this information to design a drilling mud program with sufficient hydrostatic head to overbalance the formation pressures from surface to the total depth of the well. Engineers also design the casing strings to prevent various formation conditions from affecting well control performance. Blowout preventer (BOP) equipment is installed on the wellhead after the surface casing is set and before actual drilling begins. BOP stacks are routinely tested in accordance with government requirements. Under 20 AAC 25.035, AOGCC regulates compliance with blowout prevention requirements.

b. Leak Detection

Leak detection systems and effective emergency shut-down equipment and procedures are essential in preventing discharges of oil and gas from any pipeline that might be constructed in the Sale Area. Once a leak is detected, valves at both ends of the pipeline, as well as intermediate block valves, can be manually or remotely closed to limit the amount of discharge. The number and spacing of the block valves along the pipeline will depend on the size of the pipeline and the expected throughput rate.

The technology for monitoring pipelines is continually improving. Leak detection methods may be categorized as hardware-based (optical fibers or acoustic, chemical, or electric sensors) or software-based (to detect discrepancies in flow rate, mass, and pressure). Leak detection methods include acoustic monitoring, pressure point analysis, ultrasound, radiographic testing, magnetic flux leakage, the use of coupons, regular ground and aerial inspections, and combinations of some or all of the different methods. The approximate location of a leak can be determined from the sensors along the pipeline. A computer network is used to monitor the sensors and signal any abnormal responses. In recent years, computer-based leak detection through a Real-Time Transient Model has come into use, to mathematically model the fluid flow within a pipe (Scott and Barrufet 2003). Modern pipeline systems are operated from control centers with computer connectivity and satellite and telecommunication links to strive for rapid response and constant monitoring of pipeline conditions (NRC 2003).

Design and use of “smart pigs,” data collection devices that are run through the pipeline while it is in operation, have greatly enhanced the ability of a pipeline operator to detect internal and external corrosion and differential pipe settlement in pipelines. Pigs can be sent through the pipeline on a regular schedule to detect changes over time and give advance warning of any potential problems. Three types of pigs are used. A caliper pig is used to measure internal deformation such as dents or buckling. A geometry pig records configuration of the pipeline system and determines displacement. A wall thickness pig measures the thickness of the pipeline wall. All can provide early warnings of weaknesses where leaks may occur (NRC 2003).

The FLIR pipeline monitoring program assists in detecting pipeline leaks and corrosion in the Kuparuk oil field. Originally developed by the military, FLIR uses infrared sensors to sense heat differentials. A leak shows up as a “hot spot” in a FLIR video, in both daytime and night time images. In addition, water-soaked insulation surrounding a pipeline is visible because of the heat transfer from the hot oil to the water in the insulation and finally to the exterior surface of the pipeline. FLIR is also effective in discovering water-soaked insulation areas that have produced corrosion on the exterior wall of the pipeline (NRC 2003).

FLIR also has applications in spill response. Infrared photography can be used to determine the area of a spill quickly and accurately, distinguishing between oil and substances that might look like oil to human eyes. This allows swift and accurate reporting of the spill parameters to the appropriate agencies (NRC 2003). The incident command team can receive information near real-time, and can therefore make timely decisions.

3. Oil Spill Response

Cleanup phases include initial response, remediation, and restoration. During initial response, the responsible party: gains control of the source of the spilling oil; contains the spilled oil; protects the natural and cultural resources; removes, stores, and disposes of collected oil; and assesses the condition of the impacted areas. During remediation, the responsible party performs site and risk assessments, develops a remediation plan, and removes, stores, and disposes of more collected oil. Restoration attempts to reestablish the ecological conditions that precede the spill, and usually includes a monitoring program to assess the results of the restoration activities (Jorgenson and Carter 1996).

Spill preparedness and response practices for the Sale Area are driven by the Alaska Federal/State Preparedness Plan for Response to Oil and Hazardous Substance Discharges/Releases (Unified Plan) and the North Slope Subarea Contingency Plan. The Unified and Subarea Contingency Plans represent a coordinated and cooperative effort by government agencies and were written jointly by the USCG, EPA, and ADEC (ADEC 2010, 2012).

Spill response follows the Incident Command System (ICS) outlined in the Unified Plan and the North Slope Subarea Plan. The ICS allows for all components of a response including federal, state, and local agencies; other personnel; equipment and facilities; and procedures and permitting to be managed with a common organizational structure on operating period. This coordination increases the efficiency of a response and decreases duplication of efforts. The ICS is designed to be scalable to each incident, and roles and responsibilities within the ICS are adjusted accordingly.

The ICS is led by the Unified Command, which directs all aspects of incident response (including oversight, monitoring, clean up, etc.); it also includes an Incident Commander (IC), who is in command of the control, containment, removal, and disposal of the spill. For the North Slope Subarea, the Unified Command is typically comprised of the Federal On-Scene Coordinator (FOSC), the State On-Scene Coordinator (SOSC), the Local On-Scene Coordinator (LOSC), and the Responsible Party On-Scene Coordinator (RPOSC).

The Unified Command is implemented in situations where more than one agency has jurisdiction. Under federal and state law, the Responsible Party (RP) for an oil or hazardous substance incident is required to report the incident and mount a response effort to contain and clean up the release. When the RP is identified, the RPOSC, usually a senior representative of the RP, is the Incident Commander. When there is no RP or the RP is unable to satisfactorily respond to a spill, the spill response will be directed by an IC designated by the agency with jurisdictional authority (federal, state, or local) and will follow the response protocols and guidance outlined in the Unified Plan and the North Slope Subarea Contingency Plan (ADEC 2010, 2012).

Additionally, each operator identifies a spill response team (SRT) for their facility, and each facility must have an approved contingency plan. Company teams provide on-site, immediate response to a spill event. The SRTs are integrated into the North Slope Spill Response Team (NSSRT), which is comprised of over 500 trained and qualified volunteers. The NSSRT, combined with personnel from Alaska Clean Seas, provides a minimum of 115 available field responders per day on the North Slope (ACS 2016a).

a. Prevention

i. Authorities

The North Slope Subarea Plan outlines how a spill response will be organized within the Unified Command. Participants in a spill response activities may be part of a federal, state, or local agency, local community, private or volunteer organization (ACS 2016a; ADEC 2010, 2012; AIMS Work Group 2002). Roles and responsibilities for the North Slope and the Sale Area are set out below as noted in the North Slope Subarea Plan.

Federal On-Scene Coordinator

The USCG is the lead agency for coastal oil and hazardous materials spill responses and serves as the Federal On-Scene Coordinator (FOSC) in the Unified Command. For oil spills on inland waters, more than 3000 feet inland from the tideline, the EPA will be the FOSC. The role of the USCG or EPA in the Unified Command will vary according to spill type and size. The USCG and EPA jurisdiction boundaries in the North Slope Subarea is shown in the *Alaska Clean Seas Technical Manual, Map Atlas* (ACS 2016c; ADEC 2012).

State On-Scene Coordinator

The ADEC is the lead agency for the State of Alaska in oil and hazardous materials spill response. The ADEC serves as the State On-Scene Coordinator (SOSC) in the Unified Command. The ADEC and other response personnel use the Alaska Incident Management System (AIMS) for Oil & Hazardous Substance Response which contains detailed guidance necessary to properly respond to a major spill incident (ADEC 2012; AIMS Work Group 2002).

Local On-Scene Coordinator

In the event of an oil spill or hazardous substance release in the Sale Area, a senior member of the local community with jurisdiction, unless otherwise specified by local plans, will serve as the LOSC in the Unified Command. In most cases, the NSB will provide the LOSC. For all spills in the North Slope Subarea in which the Incident Command System is implemented, the LOSC will sit in the Unified Command with the FOSC, SOSC, and RPOSC, sharing decision-making and oversight responsibilities with the other On-Scene Coordinators. For spills that affect or threaten to affect multiple jurisdictions in the North Slope Subarea, or outside of the subarea, appropriate officials from the affected communities will integrate into the command structure either through a LOSC liaison representing the affected communities or through a Regional Stakeholder Committee (ADEC 2012).

Responsible Party

Under federal and state law, the RP must contain, control, and clean up any oil or hazardous substance spilled. The RP must notify the federal, state, and local authorities of the spill incident and initiate an effective response. The RP is expected to respond to an incident using its own resources and securing additional contractual expertise and equipment when necessary. The FOSC and SOSC have the authority to oversee the RP's activities, and both are authorized to take over or supplement the RP's response activities if they determine those activities to be inadequate. During an RP-driven response, if the vessel or facility has a contingency plan, it will serve as the primary guidance document for the spill response and the RP will designate the Incident Commander. If there is no RP, or if the RP does not have a government-approved contingency plan, the Unified Plan and the North Slope Subarea Contingency Plan will become the guiding documents during the spill response (ADEC 2012).

Primary Response Actions Contractors and Oil Spill Response Organizations

Primary Response Action Contractors (RAC) and Oil Spill Response Organizations (OSRO) may play an important role in a spill response. Primary RACs and OSROs are organizations that may enter into a contractual agreement with an RP, assisting the RP in spill cleanup operations. RACs/OSROs can provide equipment, trained personnel, and additional resources. The Operations/Technical Manuals maintained by the RACs/OSROs may be referenced in vessel or facility contingency plans and serve as supplementary reference documents during a response. OSROs generally have access to large inventories of spill equipment and personnel resources. The FOSC or SOSC may contract these assets for use (ADEC 2012).

Alaska Clean Seas

Alaska Clean Seas (ACS) is a not-for-profit oil spill response cooperative whose purpose and mission are to provide personnel, material, equipment, and training to its members for responding to oil spills on the North Slope. Originally formed in 1979 under the name of ABSORB (Alaskan Beaufort Sea Oilspill Response Body) to support offshore exploration ventures in the Alaskan Beaufort Sea, ACS was restructured in 1990 from an equipment cooperative into a full-response organization capable of handling both offshore and onshore emergencies with trained responders and response equipment. Membership is optional, and member companies pay an initiation fee, annual fee, daily rig fees when engaging in drilling, and annual production fees for facilities in production (ACS 2016a).

For an oil spill in the Sale Area, oil and gas operators who are members of ACS may call upon ACS for assistance with both spill planning and response. Members may also engage in mutual aid agreements with other ACS members, providing each other with shared resources, both personnel and equipment, in the event of a spill. ACS provides manpower and equipment resources from its main base in Deadhorse and from within each of the operating oilfield units to assist in spill containment and recovery. Members are entitled to refer to ACS resources in their contingency plans, and to represent to regulatory agencies and others, that these resources are available to them in the event of a spill. Responses to oil spills in the Sale Area by ACS is exclusively for ACS organization members. However, when authorized by the Board of Directors, ACS may also respond to non-member spills. In 2016, members of ACS include Alyeska Pipeline Service Company, Anadarko Petroleum Corporation, Armstrong Energy, LLC, BP Exploration (Alaska) Inc., Brooks Range Petroleum Corporation, Caelus Energy Alaska, LLC, ConocoPhillips Alaska Inc., Eni Petroleum, ExxonMobil Alaska Production Inc., Great Bear Petroleum Operating LLC, Hilcorp Alaska, LLC, and Savant Alaska, LLC (ACS 2016a).

Regional Stakeholder Committee

A Regional Stakeholder Committee (RSC) will be activated for significant incidents to advise the Unified Command and provide recommendations or comments on incident priorities, objectives, and community concerns. RSCs do not play a direct role in setting incident priorities or allocating resources; however, the RSC can advise the Unified Command (through the Liaison Officer) and provide recommendations or comments on incident priorities, objectives, and the incident action plan. The RSC is not directly involved in tactical operations, though some of its members may be involved. Members representing RSC may vary from incident-to-incident and may include community emergency coordinators, local resource agency personnel, federal, state, local or private landowners and leaseholders, Native organizations, non-profit and volunteer organizations, and other stakeholder groups affected by the spill (ADEC 2012).

Alaska Regional Response Team

The Alaska Regional Response Team (ARRT) is a standing body established under the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (40 CFR 300.115). The ARRT is comprised of state and federal agencies with the USCG and EPA serving as co-chairs and ADEC is the state's primary representative. The ARRT provides a regional mechanism for the development and coordination of preparedness activities before a pollution response (ADEC 2010, 2012). The ARRT developed and published the *Alaska Incident Management System Guide (AIMS) for Oil and Hazardous Substance Response* that provides guidance regarding wildlife, in-situ burning, the use of dispersants, and the protection of cultural resources including archaeological and historic sites (AIMS Work Group 2002).

During a significant spill response, the ARRT members or their representatives will participate in the FOSC's ICS as appropriate. The ARRT can coordinate assistance and advice to the FOSC by providing additional federal and state resources and expediting approvals for federal and state permits. Appropriate ARRT members are convened as necessary to make decisions on in-situ burning, use of chemical countermeasures, and nationwide permits. These federal and state emergency response activities are mandates in the National Contingency Plan and are coordinated with the National Incident Management System and the National Response Framework (ADEC 2012, 2010; AIMS Work Group 2002).

Subarea Committee

The primary role of the Subarea Committee is to act as a preparedness and planning body for the subarea. Primary membership of the Subarea Committee includes the FOSC from the EPA and

USCG and the SOSC from the ADEC. Depending upon the event or the issues to be addressed, a representative from the NSB or local or tribal government representatives may also serve on the North Slope Subarea Committee. Each member is empowered by their own agency to make decisions on behalf of their organization and to commit the organization to carrying out roles and responsibilities described in the North Slope Subarea Plan and the Unified Plan (ADEC 2010, 2012).

Subarea Work Groups

Subarea work groups are established by the subarea committee as necessary to provide advice, guidance, or expertise from all appropriate sources to accomplish preparedness and planning tasks. Work group participants may include federal, state, and local agency representatives, facility owners/operators, shipping company representatives, cleanup contractors, emergency response officials, marine pilot associations, academia, environmental groups, consultants, response organizations, and representatives from any applicable regional citizens' advisory councils. The North Slope Subarea Committee formed the Sensitive Areas Work Group, the Logistics Work Group, and the Operations Work Group (ADEC 2012).

Local Governments

Local governments may respond to a spill emergency to protect life and property, and in some cases, assume the role of Incident Commander until the immediate threat to public safety is abated. Local government is closely involved in all areas of the response as it pertains to their jurisdiction and community by providing a LOSC as part of the Unified Command and a Community Emergency Coordinator when not provided by the Local Emergency Planning Committee as part of the Regional Stakeholder Committee. LOSCs should be properly trained to coordinate an emergency response involving the containment and cleanup of hazardous substances to ensure public safety and minimize contamination spreading. Additionally, local government response in no way diminishes the ultimate responsibility of the spiller who is legally and financially responsible for the cleanup (ADEC 2012).

Tribal Government

One or more of the federally-recognized tribes in the Sale Area may be involved in the response to an oil spill or a hazardous substance release. Following an oil spill or hazardous substance release that has the potential to affect tribal interests, the FOSC or SOSC will identify and notify the tribe(s) that should be alerted to the spill or release. The appropriate tribal representative(s) has an opportunity to provide input into the response process. The role and involvement of each tribal entity will vary, based on the spill response resources and capabilities that exist in the tribal government (ADEC 2012, 2010).

ii. Training

Training and spill response exercises are a key component of enhancing preparedness and response capability for the entire Alaska response community including federal, state, and local agency partners and regulated operators. Training and spill response exercises in the Sale Area may be conducted by federal, state, and local agencies, industry, and ACS (ACS 2016a; ADEC 2010, 2012). Each organization and participant have specific goals for response exercises. Regulated industries must be aware and conduct response exercises to meet the required federal National Preparedness for Response Exercise Program guidelines, state plan commitments, and other regulatory programs such as the Occupational Health and Safety Administration's Hazardous Waste Operations and Emergency Response under 29 CFR 1910.120 and 8 AAC 61 (ADEC 2010, 2012). For 2017, the ADEC is partnering with federal agencies and industry to conduct four Incident Management Team and field spill response exercises specific to the Sale Area (ADEC 2017b).

The ADEC's Interagency Coordination Unit provides coordination and facilitation for the Statewide Hazmat Response Team and Work Group. The Statewide Hazmat Response Work Group has over 25 participating entities including local, state, federal, military, private and industry hazmat response partners. The work group meets three times per year to discuss and update the following: statewide response capabilities, standardizing operating procedures, lessons learned from recent responses, training, exercises, funding, and other topics of interest. In 2016, the Statewide Hazmat Response Teams responded to three separate scenarios simulating releases of hazardous substances (ADEC 2016).

The NSSRT is made up of over 500 volunteers that are trained and qualified for spill response on the North Slope. ACS conducts joint training exercises with the NSSRT. The NSSRT combined with ACS personnel provide a minimum of 115 spill response personnel available on the North Slope each day. ACS also organizes and trains the Auxiliary Contract Response Team (ACRT) which provides additional spill response personnel as needed. The personnel are provided through ACS contracts with when additional spill response personnel are needed. In 2016, ACS contracted with CCI Industrial Service, PENCO Environmental Services, and National Response Corporation Alaska. Over 700 qualified spill responders were available through these contracts (ACS 2016a).

iii. Research and Development

Building on studies addressing Arctic oil spill response, ACS developed a technical manual for spill response on the North Slope and Beaufort Sea. The three-volume manual was revised in 2008. The manual and the background documents supporting it are a compilation of the latest research and best available technology regarding oil spill response in the Arctic. The response tactics in the manual are designed to be used as building blocks for operators to prepare facility-specific response scenarios in their contingency plans. The manual describes key response planning parameters for a variety of climatic and environmental conditions that may be encountered. It is intended to provide direction and consistency in developing generic scenarios for a variety of receiving environments, and eliminate the need for individual plans to repeat technical details. The manual consists of three volumes: Tactics Descriptions, Map Atlas, and North Slope Incident Management System which augment the contingency plans that each operator must prepare before beginning operations (ACS 2016a, b, c). The manual represents a major advance in the organization and coordination of spill response planning and preparedness on the North Slope.

ACS acts as a facilitator for much of the research and development related to responding to spills in the Arctic. Research focuses on oil recovery techniques in, on, and under ice, and during various broken ice conditions, as well as detecting and tracking oil under ice, tundra treatment, high volume skimmers, ground penetrating radar, and alternative response options. ACS also manages research and development projects for BP Exploration, Inc., and ConocoPhillips Alaska, Inc., to meet the requirements to the Charter for Development of the Alaskan North Slope commitment to the State of Alaska (ACS 2016a).

b. Response and Remediation

i. Spill Response

Response actions vary greatly with the nature, location, and size of the spill. A spill response progresses through a series of steps where the number of personnel and amount of equipment are increased or decreased as necessary to meet the demands of the situation. This increase of resources to address response needs is called a ramp up. The USCG and EPA will rely on their respective agency's Incident Management Handbooks and State of Alaska personnel will employ the AIMS Guide and well as the Spill Tactics for Alaska Responders (STAR) to direct their staffing of emergency response teams (ADEC 2012; AIMS Work Group 2002).

The ramp up begins when the spill is first reported and progresses with the sequential and prioritized activation of the response resources of the RP and the local, state, and federal responders. Each spill response will differ according to spill size and severity, location, season, and personnel needs will vary accordingly. Response teams consider all factors that may affect the situation and revise, modify, or expand these priorities as the situation dictates. The strategies listed in the Unified Plan and the North Slope Subarea Plan should be used as a guide in developing an effective response (ADEC 2010, 2012). Additionally, the ACS Technical Manual provides specific tactics, strategies, and the resources necessary to support a given strategy (ACS 2016b). In addition to federal and state responders, local agencies may also have trained personnel available to help staff an ICS.

Within the State of Alaska, three types of responses are generally recognized by the spill response community. These are as follows:

Responsible Party-Led Response

Under this type of response, the RP assumes responsibility and actively engages in response and cleanup activities. The RP, either directly or through a spill cooperative, activates the contingency plan and staffs the incident response organization. The federal and state entities assume an oversight role to monitor the adequacy of the RP's efforts, perform required regulatory functions such as investigation, damage assessment, and cost recovery, and jointly develop response objectives.

Responsible Party Augmented Response

In certain circumstances such as a catastrophic spill event or an RP with limited capabilities, the RP may require additional assistance from the federal or state governments to launch an adequate response and sustain a cleanup operation. The lead federal and state agencies may augment the RP's efforts as necessary, including staffing of the incident response organization and providing additional spill response resources. The federal and state authorities will also continue with their regulatory functions as well.

Government-Led Response

In the event of a non-responsive, incapable, or unknown RP, the appropriate federal (USCG or EPA) or state agency (ADEC) who has jurisdiction over the incident will take the lead and manage the response and cleanup operation. In doing so, the government agency(s) will staff the response organization and direct the response and cleanup operation which may be delegated to federal or state response contractors.

There are four types of incidents: minor (Type Four), medium (Type Two and Three), and major (Type One). Type Four Incidents are characterized as small incidents that can be managed with local resources (normally one response individual), involve no casualties or injuries, are limited in volume (generally less than 55 gallons in the case of an oil spill), and have minimal impact. Type Three Incidents are characterized as regional incidents that may require activation of other area team resources, require a response staff of 2 to 10 personnel, involve a larger release volume (greater than 55 gallons in the case of an oil spill), and have potential for moderate impacts. Type Two Incidents are characterized as statewide incidents that will require activation of other area team resources, require a response staff of more than 10 personnel, involve a significant release volume (greater than 100,000 gallons in the case of an oil spill), and have a high potential for moderate impacts. Type Two incidents result in expenditures greater than $100,000 and may cover large geographic areas. Type One Incidents are characterized as statewide incidents that involve oil spill volumes in excess of 1,000,000 gallons, require statewide resources and a very large response staff of greater than 20 personnel, and will result in severe impacts to the environment. Type One incidents result in expenditures greater than $1,000,000 and may cover large geographic areas (ADEC 2010).

Operators on oil and gas leases are the primary persons responsible for planning for, implementing and completing an approved plan of operations, which includes provisions for operations, supplies, equipment, access, facilities and rehabilitation of the affected lease area. Additionally, fire department personnel in nearby villages may be called to respond to fire incidents. Utqiaġvik has full-time fire department assisted by volunteers, and Anaktuvuk Pass, Nuiqsut, and Kaktovik have mostly volunteer fire departments with one or two paid employees. Others trained in fire response could be called to an oil and gas related fire event (ADEC 2012; AIMS Work Group 2002).

ACS and the North Slope operators employ a tiered system of Mutual Aid Emergency Response Levels for responding to spills covered under Mutual Aid Agreements. Tier One spills are small non-emergency spill incidents in which the area resources can effectively respond to the spill without assistance. Spills requiring the resources of ACS and the responsible party's Spill Response Technician are considered Tier One spills. A Tier Two spill incident requires more resources in the immediate area than that of ACS and the RP, but the resources required are still available on the North Slope. Such spills usually require some longer-term cleanup. A Tier Three spill is an extremely large incident or an incident lasting several months that may require resources unavailable on the North Slope. Resources are available through Master Service Agreements and ACS may enlist assistance from spill responders from Cook Inlet (CISPRI) and Prince William Sound or from its ACRT subcontractors: CCI, Penco, and Trident, as well from across the United States and other countries (ACS 2016a). Response strategies are set forth in ACS Technical Manual, providing specific scenarios for environmental and seasonal conditions found on the North Slope (ACS 2016b, c).

There are emergency operation centers located in Deadhorse, at satellite areas in Alpine, Kuparuk, Milne Point fields, and at the Prudhoe Bay Operations Center. With assistance from the ACS base operations center, field-assigned ACS technicians support the operating area facilities and sites, while the Deadhorse locations are managed by ACS base personnel. Mobile facilities are also available (ACS 2016a).

ACS established a central Incident Command Post at Deadhorse as a control point for oil spill response radio and telephone systems for the entire North Slope which includes the Sale Area, and extends into the Beaufort Sea. This radio and telephone communications system is capable of being rapidly deployed by sea, land, or air to local and remote areas in support of onshore or offshore oil spill response actions (ACS 2016a, b).

ii. Fate and Behavior of Spilled Oil

Spills in the Arctic require careful preplanning to overcome the effects imposed by the cold-weather environment. Machinery and people face significant challenges when operating in acute cold. Quick response and recovery greatly affect the efficacy of any spill cleanup. After a spill, the physical and chemical properties of the individual constituents in the oil begin to be altered by the physical, chemical, and biological characteristics of the environment. These are called weathering, evaporation, oxidation, dispersion, dissolution, biodegradation, and emulsification (ADEC 2012).

The various types of petroleum products respond quite differently when released into the environment. Spills of refined product that enter the water generally will disperse and experience significant evaporation, making recovery difficult. Crude oil will be affected by the same natural degradation factors but to a much lesser degree. Crude oil spills are “persistent” in nature and require aggressive actions and innovative techniques to be successful in the harsh Arctic environment. The passage of time before the start of recovery allows oil to spread, expanding the affected area and thus requiring more response resources (ADEC 2012).

Upland spills follow topography; oil flows downhill. If released to tundra, summertime spills penetrate soil and foul tundra. Wintertime spills may be constrained or facilitated by snow and ice. Ice and snow can act effectively as natural barriers by impeding the spread of oil, and can be used effectively to create berms for spill containment (NRC 2003).

The factors that are most important during the initial stages of cleanup are the evaporation, solubility, and movement of the spilled oil. As much as 40 percent of most crude oils may evaporate within a week after a spill. Over the long term, microscopic organisms (bacteria and fungi) break down oil (Jorgenson and Carter 1996). Understanding these processes is critical to decisions about cleaning spilled oil.

iii. Cleanup Techniques and Remediation

Cleanup plans, regardless of the location and nature of the spill, must balance the objectives of maximizing recovery and minimizing ecological damage. All oils are not the same, and knowledge of the chemistry, fate, and toxicity of the spilled oil can help identify cleanup techniques that can reduce the ecological impacts of an oil spill. Hundreds of laboratory and field experiments have investigated the fate, uptake, toxicity, behavioral responses, and population and community responses to crude oil.

Cleanup plans must also address the complications of working in Arctic conditions including extreme cold, ice, and darkness. The North Slope can present extremes that might make it difficult to effectively contain and clean up a major spill. Cold weather, in particular, can challenge both personnel and machinery. Conversely, ice and snow can act as natural barriers and facilitate clean up. However, spills that occur during the summer risk impacting the diverse species that use habitats in the Sale Area. Cleanup plans address specific steps to accommodate these conditions. The effects on the sensitive environments of the region could be severe if they are not mitigated (NRC 2003; Nuka Research and Planning Group LLC 2007).

The best cleanup techniques are those that quickly remove volatile aromatic hydrocarbons. This portion of oil is related to the physical fouling of birds and mammals. To limit the most serious effects, it is desirable to remove the maximum amount of oil as soon as possible after a spill. The objective is to promote ecological recovery and not allow the ecological effects of cleanup to exceed those caused by the spill itself (Jorgenson and Carter 1996).

State regulations require operators to be able to mechanically entrain and recover, within 72 hours, a response planning standard (RPS) volume of oil (18 AAC 75.434). For exploration facilities, the RPS is a minimum of 16,500 barrels plus 5,500 barrels for each of 12 days beyond 72 hours. For production facilities, the RPS is, at a minimum, three times the annual average daily production for the maximum producing well at the facility. If well data demonstrate a lower RPS is appropriate, it may be adjusted accordingly (Nuka Research and Planning Group LLC 2007).

4. Hazardous Substances

Hazardous substances are identified as a large range of elements, compounds, and substances regulated by the EPA, USCG, ADEC, and other government agencies. In addition to petroleum products, waste products, toxic water pollutants, hazardous air pollutants, hazardous chemical substances, and other products presenting an imminent danger to public health or welfare are identified for prevention from release and response in cases of spills. AS 46.03.826(5). The four most extremely hazardous substances in the North Slope Subarea are: 1) sulfuric acid, 2) hydrochloric acid, 3) hydrogen peroxide, and 4) chlorine. The ADEC, USCG, and EPA monitor and inspect operations and facilities in the Sale Area to enforce compliance with preventative measures to ensure safe use and storage of hazardous substances (ADEC 2012). In order to minimize releases or spills during oil and gas operations, mitigation measures have been developed and can be found in Chapter 9.

Spill response protocols are well established for the North Slope Subarea. The DEC, USCG and EPA – Region 10 have established guidelines for operations in the event of a major response effort to an oil spill or hazardous material release in the North Slope Subarea Contingency Plan. Any release of a hazardous substance must be reported by a RP as soon as the person has knowledge of the discharge. The release must be reported to the National Response Center and the ADEC and response protocols are initiated. There are a number of safeguards in place to react quickly to hazardous releases. Coordination, trained personnel, and technological advances can be employed quickly to address the occasions when releases occur (ADEC 2012).

It is essential for those in command control to recognize and identify the substance release for safe containment. An initial characterization of the hazard during the evaluation phase of containment requires an assessment of potential threat to public health and environment, need for protective actions, and protection of response personnel. A more comprehensive characterization will follow if necessary. In certain cases, local or state entities have the authority to order evacuations beginning with those living or working in downwind or in low-lying areas. Response personnel will secure sites, establish control points, and establish work zones. The LOSC is in command and control until he or she determines an imminent threat to public safety no longer exists. While the largest volume of transport hazard substances are natural gas and crude oil, agency coordination between federal, state, and local entities are equipped to contain and manage releases of all hazardous substances present in the Sale Area (ADEC 2012).

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Chapter Seven: Governmental Powers to Regulate Oil and Gas

Contents

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AS 38.05.035(g)(1)(B)(v) requires the director to consider and discuss the governmental powers to regulate the exploration, development, production, and transportation of oil and gas or gas only. Oil and gas activities are subject to numerous federal, state and local laws, regulations, policies, and ordinances. Each lessee is obligated to comply with all federal, state, and local laws. Regulatory agencies may have different roles in the oversight and regulation of oil and gas activities, and some agencies may have overlapping authorities with other agencies.

Most oil and gas activities require individual authorizations regardless of which phase (exploration, development, production, or transportation) of oil and gas development they are associated with. Common oil and gas activities associated with exploration requiring prior authorization include seismic surveys, development of drill pads, and drilling exploration wells. In the development phase, common activities requiring prior authorization include construction of pads, roads, support facilities, and drilling development wells. In the production phase, common oil and gas activities requiring prior authorization include constructing and operating processing facilities, construction of transmission pipelines, flow lines, and above-ground storage tanks. The transportation phase is focused on moving oil and gas, and regulatory authorities tend to shift toward monitoring activities and facilities in the field to ensure post-disposal oil and gas activities are conducted as approved. These phases are not always sequential and associated oil and gas activities may occur at any point throughout the project. The completion of one phase does not automatically trigger the beginning of a new phase.

This chapter is not intended to provide a comprehensive description of the broad spectrum of government agencies authorized to prohibit, regulate, and condition oil and gas activities which may ultimately occur as a result of the North Slope Areawide lease sales. Actual processes, terms, conditions, and required authorizations will vary with time-certain, site-specific operations, and the activities discussed in the previous paragraph are not all inclusive. Lessees are responsible for knowing and complying with all applicable federal, state, and local laws, regulations, policies, ordinances, and the provisions of the lease. Some, but not all, of the major permits and approvals required by each agency are discussed below.

A. State of Alaska

The State of Alaska has several agencies that approve, oversee, or coordinate activities related to oil and gas exploration, development, production, and transportation.

1. Department of Natural Resources (DNR)

a. Oil and Gas Lease

The Division of Oil and Gas (DO&G) has the authority to issue oil and gas leases. An oil and gas lease grants to the lessee, without warranty, the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances in or under a specific tract of land. While an oil and gas lease grants the lessee exclusive rights to subsurface mineral interests, it does not authorize subsequent activities on the lease.

b. Plan of Operations Approval

Operations undertaken on or in the leased or the unit area are regulated by 11 AAC 83.158 and 11 AAC 83.346. An application for approval of a plan of operations must contain sufficient information for DO&G to determine the surface use requirements and impacts directly associated with the proposed operations. Amendments may be required as necessary, but DO&G will not require an amendment that is inconsistent with the terms of the sale under which the lease was obtained. The terms and conditions of the lease, including amendments to the plan of operations, are attached to the plan of operations approval and are binding on the lessee. The lessee is required to keep the leased or unit area open for inspection by authorized state officials. Several state agencies including the DNR, Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADF&G), and Alaska Oil and Gas Conservation Commission (AOGCC) may monitor field operations for compliance with each agency’s terms. In addition to an approved plan of operations, a bond must be furnished to DNR in accordance with 11 AAC 83.160, before starting operations on a state oil and gas lease.

c. Pipeline Rights-of-way

In 1987, the State Pipeline Coordinator’s Office was established within DNR. Administrative Order 187 established the State Pipeline Coordinator’s Office as the lead agency for the state in processing pipeline right-of-way leases under AS 38.35, the Right-of-Way Leasing Act. This responsibility includes coordination of the state’s efforts related to the federal right-of-way process. The State Pipeline Coordinator also coordinates the state's oversight of preconstruction, construction, operation and termination of jurisdictional pipelines. In July 2015, the State Pipeline Coordinator’s Office was incorporated into the organizational structure of DO&G as the State Pipeline Coordinator’s Section (SPCS 2017).

d. Temporary Water Use Authorization

Exploration activities may require a temporary water use authorization. The Division of Mining, Land, and Water (DMLW) administers temporary water use authorizations as required under 11 AAC 93.035 before (1) the temporary use of a significant amount of water, (2) if the use continues for less than five consecutive years, and (3) the water applied for is not otherwise appropriated (DMLW 2016). The volume of water to be used and permitted depends upon whether it is for consumptive or non-consumptive uses, and the duration of use. The authorization may be extended one time for good cause for a period of time not to exceed five years.

The authorization is subject to conditions and may be suspended or terminated if necessary to protect the water rights of other persons or the public interest. Information on lake bathymetry, fish presence, and fish species may be required when winter water withdrawal is proposed to calculate the appropriate withdrawal limits.

e. Permit and Certificate to Appropriate Water

Industrial or commercial water use requires a Permit to Appropriate Water under 11 AAC 93.120. The permit is issued for a period of time consistent with the public interest and adequate to finish construction and establish full use of water. The maximum time period for this permit is five years, unless the applicant proves or the commissioner independently determines a longer period is required. The commissioner may issue a permit subject to terms, conditions, restrictions, and limitations necessary to protect the rights of others, and the public interest. Under 11 AAC 93.120(e), permits are subject to conditions to protect fish and wildlife habitat, recreation, navigation, sanitation or water quality, prior appropriators, or any other purpose the department determines is in the public interest.

A Certificate of Appropriation will be issued under 11 AAC 93.130 if the permit holder remits the fee required under 11 AAC 05.010 and: (1) submits a statement of beneficial use stating that the means necessary for the taking of water have been developed and the permit holder is beneficially using the quantity of water to be certificated, and (2) has substantially complied with all permit conditions.

f. Land Use Permits

The DO&G issues land use permits, also known as a geophysical permit or a miscellaneous land use permit, under 11 AAC 96.010. Geophysical exploration permits are required for all geophysical and exploration activity in the North Slope area. All state land in townships within the Umiat Meridian are designated special use lands, regardless of whether the applicant holds a lease or other property interest in the Sale Area (11 AAC 96.014(b)(1)). Alaska Division of Lands file number 50666 identifies geophysical, other exploration, construction, and transportation activities to require a land use permit under 11 AAC 96.010. Submission of seismic exploration and stratigraphic test data to the state is required as a condition of the issuance of a land use permit to conduct seismic exploration field operations or to drill a stratigraphic test well under 11 AAC 96.210.

The DMLW issues land use permits to manage surface uses and activities on state public domain land and to minimize adverse effects on the land and its resources under 11 AAC 96. Land use permits may be required for some oil and gas activities, unless the activities are otherwise approved under any department-administered lease, oil and gas exploration license, plan of operations, contract, or permit (11 AAC 96.007). Land use permits may be issued for a period of up to five years depending on the activity, and may be revoked at will or for cause in accordance with 11 AAC 96.040. Generally allowed uses on state land are subject to the conditions set out in 11 AAC 96.025.

g. Material Sale Contract

If the operator proposes to use state-owned gravel or other materials for construction of pads and roads, DMLW requires a material sale contract (11 AAC 71). The contract must include, at a minimum, a description of the Sale Area, the materials to be extracted, the volume of material to be extracted, the method of removal of the material, the bonds and deposits required of the purchaser, and the purchaser’s liability under the contract. The material sale contract must also include the purchaser’s site-specific operating requirements (11 AAC 71.200).

A contract may be extended if the DMLW director determines the delay in completing the contract is due to unforeseen events beyond the purchaser's control, or the extension is in the state's best interests (11 AAC 71.20).

The DMLW director may require the purchaser to provide a performance bond guaranteeing performance of the terms of the contract. If required, the bond amount is based on the total value of the sale and must remain in effect for the duration of the contract unless released in writing by the DMLW director (11 AAC 71.095).

h. Office of History and Archaeology (OHA)

The OHA performs the work of the State Historic Preservation Office (SHPO) (OHA 2015b). OHA follows the state's historic preservation plan in maintaining the Alaska Heritage Resources Survey (AHRS). The historic preservation plan was last updated in 2011 and is current through 2017. A revised plan that will guide preservation activities in the state from 2018 through 2023 was approved by the National Park Service in December 2017. A final version of the plan is scheduled to be released in late winter 2018.

AHRS is an inventory of all reported historic and prehistoric sites within the state. This inventory includes objects, structures, buildings, sites, districts, and travel ways, with a general guideline that the sites are over 50 years old. The fundamental use of the AHRS is to protect cultural resource sites from unwanted destruction (OHA 2015a). Before beginning a multi-phase development project, information regarding important cultural and historic sites should be obtained by contacting the OHA. The AHRS data sets are "restricted access documents" and site-specific location data should not appear in final reports or distributed to others.

AS 41.35.010 enables the state to preserve and protect the historic, prehistoric, and archeological resources of Alaska from loss, desecration, and destruction so the scientific, historic, and cultural heritage embodied in these resources may pass undiminished to future generations. Further, the historic, prehistoric, and archeological resources of the state are properly the subject of concerted and coordinated efforts exercised on behalf of the general welfare of the public so these resources may be located, preserved, studied, exhibited, and evaluated.

2. Department of Environmental Conservation (ADEC)

The ADEC has the statutory responsibility to conserve, improve, and protect Alaska's natural resources and environment, by regulating air, land, and water pollution, and oil spill prevention and response. The ADEC implements and coordinates several federal regulatory programs in addition to state laws (ADEC 2016d).

a. Interference with Salmon Spawning Permits

The ADEC is responsible for issuing permits for activities that interfere with salmon spawning streams and waters. If a person plans to obstruct, divert, or pollute waters of the state used by salmon in the propagation of the species, they must first apply for and obtain a permit before beginning any activities (AS 16.10.010).

Permits may be granted if ADEC finds the purpose of the permit is to develop power, obtain water for civic, domestic, irrigation, manufacturing, mining, or other purposes with the intent to develop the state's natural resources. The applicant may also be required to construct and maintain adequate fish ladders, fishways, or other means by which fish may pass over, around, or through the dam, obstruction, or diversion in the pursuit of spawning.

b. Air Quality Permits

The ADEC administers the federal Clean Air Act (42 U.S.C. §§ 7401–7671 et seq.) and the state's air quality program under a federally-approved State Implementation Plan (AS 46.14; 18 AAC 50). Through this plan, federal requirements of the Clean Air Act are met, including National Ambient Air Quality Standards (NAAQS), Non-Attainment New Source Review (N-NSR), New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and Prevention of Significant Deterioration (PSD). Additionally, the ADEC monitors air quality and compliance.

The NAAQS set limits on certain pollutants (called criteria pollutants) considered harmful to public health and the environment. NAAQS have been established for: carbon monoxide, lead, nitrogen dioxide, particulate matter (PM10), small particulate matter (PM2.5), ozone, and sulfur dioxide. N-NSR, a permitting program required for new construction projects, ensures that air quality is not degraded by the new project, and that large new or modified industrial sources are as clean as possible (EPA 2016c). NSPS are intended to promote the use of the best air pollution control technologies available, and account for the cost of technology and any other non-air quality, health, and environmental impact and energy requirements (EPA 2016b). NESHAPs are set for air pollutants that are not covered by NAAQS, but that may be harmful (EPA 2017). The standards are categorized by type of source, and require the maximum degree of reduction in emissions that is achievable, as determined by the US Environmental Protection Agency (EPA).

The two primary types of permits issued to meet these requirements are Title I Construction Permits and Title V Operation Permits (ADEC 2016a). These permits specify what activities are allowed, what emission limits must be met, and may specify how the facility must be operated. The permits may contain monitoring, recordkeeping, and reporting requirements to ensure that the applicant meets the permit requirements (ADEC 2016a).

i. Title I (NSR/PSD) Construction Permits

Title I permits refer specifically to air construction permits and minor source specific permits for the PSD as well as other requirements of the Clean Air Act. This permit must be obtained before onsite construction can begin. Operators of existing and new facilities who propose to construct or modify a stationary source may need to apply for a construction or minor source specific permit. Title I permits are required for projects that are new major sources for pollutants, or major modifications at existing sources. PSD requires installation of the "Best Available Control Technology (BACT)"; an air quality analysis; an additional impacts analysis; and public involvement (EPA 2016d).

The Title I permitting process may include pre-application meetings between the applicant and the ADEC. Upon receiving a complete application, the ADEC will approve or deny the application. If the application is approved, a 30-day public notice is issued which includes the preliminary permit and a Technical Analysis Report. After the public notice period closes, the ADEC will decide whether to issue a final permit after taking into consideration any comments received during the public comment period. The final permit package includes a final Technical Analysis Report and response to comments if applicable.

The process for a Title I permit can take up to three years, depending on the amount of meteorological or pollutant data collection required. Once a complete Title I permit application is submitted, ADEC strives to issue Title I minor permits within 130 days. Title I PSD permits can take up to 18 months to issue once a complete permit application is received. Article 5 of 18 AAC 50 contains the regulations covering Title I minor permits. Article 3 of 18 AAC 50 contains the regulations covering the Title I PSD permits. With a few exceptions, ADEC has adopted the federal PSD permit program under 40 CFR 52.21 by reference.

ii. Title V Operations Permits

The federal Clean Air Act gives EPA authority to limit emissions from air pollution sources after the source has begun to operate. EPA regulations require facilities that emit certain pollutants or hazardous substances to obtain a permit to operate the facility, known as a Title V permit. In Alaska, ADEC is responsible for issuing Title V permits and making compliance inspections (AS 46.14; 18 AAC 50). The permit establishes limits on the type and amount of emissions, requirements for pollution control devices and prevention activities, and requirements for monitoring and record keeping (ADEC 2016a).

If a Title V permit is required, permittees have up to one year after beginning operations to submit their completed Title V permit application. Operations can continue while ADEC processes the application if the application is both timely and complete. However, significant revisions to an existing permitted facility cannot be made until ADEC approves the permit revision. Processing time for permit revisions can take up to six months. Title V permits and revisions can be processed concurrently with Title I permits. Article 3 of 18 AAC 50 contains the regulations covering Title V permits. With a few exceptions, ADEC has adopted the federal operating permit program under 40 CFR Part 71 by reference.

iii. Other Requirements

The ADEC also operates ambient air quality monitoring networks under the PSD Program to: assess compliance with the NAAQS for carbon monoxide, particulates, nitrogen dioxide, sulfur oxide, and lead; assesses ambient air quality for ambient air toxics levels; provides technical assistance in developing monitoring plans for air monitoring projects; and issues air advisories to inform the public of hazardous air conditions (ADEC 2016c).

Operators in Alaska are required to minimize the volume of gas released, burned, or permitted to escape into the air (20 AAC 25.235(c)). Operators must report monthly to the Alaska Oil and Gas Conservation Commission (AOGCC) any flaring event lasting over an hour. The AOGCC investigates these incidents to determine if there was unnecessary waste (AOGCC 2004).

c. Solid Waste Disposal Permit

The ADEC regulates solid waste storage, treatment, transportation, and disposal under 18 AAC 60. EPA administers the Resource Conservation and Recovery Act (RCRA) relating to hazardous wastes and Underground Injection Control (UIC) Class I injection wells. A different state agency, the AOGCC, regulates UIC Class II oil and gas waste management wells.

The ADEC requires a comprehensive disposal plan for all solid waste disposal facilities it regulates. Solid waste disposal permit applications are reviewed for compliance with air and water quality standards, wastewater disposal, and drinking water standards, and consistency with the Alaska Historic Preservation Act before approval.

Non-drilling related solid waste must be disposed in an approved municipal solid waste landfill (MSWLF). MSWLFs are regulated under 18 AAC 60.300–398. All other solid waste (except for hazardous materials) must be disposed in an approved monofill (18 AAC 60.400–495). Solid waste general permits are available for the operation and maintenance of a storage facility for drilling waste generated on the North Slope. A general permit allows for temporary storage of drilling waste prior to permanent disposal or remediation.

All produced waters must be reinjected down well or treated to meet Alaska Water Quality Standards before discharge. Drilling waste disposal is specifically regulated under 18 AAC 60.430. Design and monitoring requirements for drilling waste disposal facilities are identified in 18 AAC 60.430(c) and (d). Hazardous substances disposal is covered under a separate permitting and review process by both ADEC under 18 AAC 62 and 63 and the EPA.

d. Wastewater Disposal Permit

Domestic graywater must be disposed of properly at the surface and requires a wastewater disposal permit (18 AAC 72). Monitoring records must be available for inspection, and a written report may be required upon completion of operations.

e. APDES Discharge Permits and Certification

The ADEC administers the Alaska Pollution Discharge Elimination System (APDES) program (ADEC 2016b). This program regulates discharges of pollutants into United States waters by “point sources,” such as industrial and municipal facilities. Permits are designed to maximize treatment and minimize harmful effects of discharges.

APDES covers a broad range of pollutants, which are defined as “any type of industrial, municipal, and agricultural waste discharged into water” (18 AAC 83.990).

There are two basic types of APDES permits: general permits and individual permits. General permits cover multiple facilities that have similar wastewater characteristics in a defined area. Individual permits are issued to a single facility and the terms, limits, and conditions are specifically tailored for that facility and circumstances. APDES permits are effective for a period not exceeding five years, and must be renewed before it expires.

f. Industry Oil Discharge Prevention and Contingency Plans

The ADEC regulates spill prevention and response under AS 46.04.030. The ADF&G and DNR support the ADEC in these efforts by providing expertise and information. Contingency plans (C-plans) must be filed with the ADEC before beginning operations. The DNR reviews and provides comments to the ADEC regarding the adequacy of these C-plans.

C-plans for exploration facilities must include a description of methods for responding to and controlling blowouts, the location and identification of oil spill cleanup equipment, the location and availability of suitable drilling equipment, and an operations plan to mobilize and drill a relief well. Holders of approved plans are required to have sufficient oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the particular type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)). If development and production follow, additional contingency plans must be approved for each facility before activity commences.

Discharges of oil or hazardous substances must be reported to ADEC that record the volume released, whether the release is to land or to water, and whether the release has been contained by secondary containment or a structure. The discharge must be cleaned up to ADEC's satisfaction. ADEC will modify proposed cleanup techniques or require additional cleanup techniques for the site as ADEC determines to be necessary to protect human health, safety, welfare, and the environment (18 AAC 75.335(d)).

C-plans must describe existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation (AS 46.04.030; 18 AAC 75.425(e)(2)(E)). C-plans must include: a Response Action Plan, a Prevention Plan, and Supplemental Information to support the response plan, including a Best Available Technology Section (18 AAC 75.425). Operators must also provide proof of financial ability to respond to damages (AS 46.04.040).

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

a. Fish Habitat Permit

Under AS 16.05.841–871, the ADF&G has the statutory responsibility for protecting freshwater anadromous fish habitat and providing free passage for anadromous and resident fish in freshwater bodies. Any activity or project that is conducted below the ordinary high-water mark of an anadromous stream. These activities include, but are not limited to, construction and maintenance for bridges and culverts, ice roads and bridges, stream diversion, stream crossing, and using explosives in the bed of a specified river, lake, or stream. The ADF&G may attach additional stipulations to any permit authorization to mitigate potentially negative impacts of the proposed activity.

b. Special Area Permit

Under AS 16.20, authorization for land and water use activities that may impact fish, wildlife, habitats, or existing public use in any of the refuges, sanctuaries, or critical habitat areas designated by the Alaska State Legislature, may require a special area permit. Examples of activities requiring a special area permit include, but are not limited to, construction or placement of structures, damaging or clearing vegetation, detonation of explosives, natural resource development or energy exploration, and any activity that is likely to have a significant effect on vegetation, drainage, water quality, soil stability, fish, wildlife, or their habitat, or which disturbs fish or wildlife (5 AAC 95.420). The ADF&G may require a mitigation plan pursuant to 5 AAC 95 when deemed necessary.

4. Alaska Oil and Gas Conservation Commission (AOGCC)

The AOGCC is an independent, quasi-judicial agency of the State of Alaska. Established under the Alaska Oil and Gas Conservation Act, AS 31.05.005, the AOGCC has statutory mandates consistent with the protection of health, safety, and the environment. The AOGCC's regulatory authority is outlined in 20 AAC 25.

The AOGCC acts to prevent waste, protect correlative rights, improve ultimate recovery, and protect underground freshwater. It issues permits, orders, and administers the Underground Injection Control (UIC) program for enhanced oil recovery and underground disposal of oil field waste. The AOGCC serves as an adjudicatory forum for resolving certain oil and gas disputes between owners, including the state (AOGCC 2015).

a. Permit to Drill

Under AS 31.05.090, the AOGCC is authorized to issue permits to drill. Anyone wishing to drill a well for oil, gas, or geothermal resources first must obtain a permit to drill from the AOGCC. This requirement applies to exploratory, stratigraphic test and development wells, and injection and other service wells related to oil, gas, and geothermal activities. Typically, operating companies have obtained approval from all other concerned agencies by the time an operator, as defined by 20 AAC 25.990(46), applies to the AOGCC for a permit to drill. The application must be accompanied by the items set out in 20 AAC 25.005(c).

Under 20 AAC 25.015, once a permit to drill has been approved, the operations detailed in the permit to drill application must not be changed without additional approval from the AOGCC. After issuance of a permit to drill, information on the surface and proposed bottom-hole locations and the identity of the lease, pool, and field for each well is published as part of the AOGCC's weekly drilling report (AOGCC 2015).

b. Underground Injection Control Program (UIC)

The goal of the UIC program is to protect underground sources of drinking water from contamination by oil and gas (Class II) injection activities. The UIC program requires the AOGCC to verify the mechanical integrity of injection wells, determine if appropriate injection zones and overlying confining strata are present, determine the presence or absence of freshwater aquifers and ensure their protection, and prepare quarterly reports of both in-house and field monitoring for the EPA. Through a Memorandum of Understanding with the EPA, the AOGCC has primacy for Class II wells in Alaska, including oilfield waste disposal wells, enhanced oil recovery wells, and hydrocarbon storage wells.

The AOGCC reviews and takes appropriate action on proposals for the underground disposal of Class II oil field wastes (20 AAC 25.252). Before receiving approval, an operator must demonstrate that injected fluids will not move into freshwater sources. Disposal or storage wells must be cased and the casing cemented in a manner that will isolate the disposal or storage zone and protect oil, gas, and freshwater sources. Once approved, liquid waste from drilling operations may be injected through a dedicated tubing string into the approved subsurface zone. The pumping of drilling wastes through the annular space of a well is an operation incidental to drilling of the well, and is not a disposal operation subject to regulation as a Class II well (AOGCC 2015).

c. Annular Disposal of Drilling Waste

An AOGCC permit is required if waste fluid is to be injected into a well annulus. The material must be muds and cuttings incidental to the drilling of a well. The AOGCC considers the volume, depth, and other physical and chemical characteristics of the formation designated to receive the waste. Annular disposal is not permitted into water bearing zones where dissolved solids or salinity concentrations fall below predetermined threshold limits. Waste not generated from a hydrocarbon reservoir cannot be injected into a reservoir (AOGCC 2015).

d. Disposal Injection Orders

Under 20 AAC 25.252, operators may apply for disposal injection orders to dispose of waste in individual wells. After the public review process and the AOGCC analysis, an order may be issued that approves the proposed disposal project (AOGCC 2015).

e. Area Injection Orders

Injection orders may be issued on an area basis rather than for individual wells in areas where greater activity is anticipated (20 AAC 25.402). The area injection orders describe, evaluate, and approve subsurface injection on an area wide basis for enhanced oil recovery and disposal purposes (AOGCC 2015).

f. Flaring Oversight

The goal of the flaring oversight program is the elimination of unnecessary flaring whenever possible in accordance with 20 AAC 25.235. Operators are required to report all flaring events lasting longer than one hour to the AOGCC. Flaring events over one hour are analyzed and investigated if necessary. The operator may be penalized if it is determined that waste has occurred (AOGCC 2015).

5. Department of Labor and Workforce Development (DOLWD)

In response to studies of the state’s workforce by the DOLWD that identified the need to increase the supply of skilled construction workers available in the state, Governor Walker signed Administrative Order No. 278 (AO 278). AO 278 states that increasing opportunities for on-the-job training through monitoring the use of apprentice workers on state-financed construction projects will work to improve the future pool of skilled construction workers available. AO 278 requires the commissioners of the Department of Transportation and Public Facilities and the Department of Administration to strive to require that not less than 15 percent labor hours on a qualified project are performed by federally-registered apprentices in certain job classifications, and directed the DOLWD to collect information related to compliance with AO 278 and submit the requisite reports to the governor. Additionally, DNR was directed to, in the development of Best Interest Findings for disposal of mineral and oil and gas leases, seek input from other agencies and include a discussion of the potential benefits of the lessee’s hiring and employment of apprentices to perform at least 15 percent of total work hours. As to existing leases, DNR was directed to consider ways to encourage lessees developing minerals, including oil and gas, on state-owned land to employ apprentices for work performed on the leased area (Governor Bill Walker 2015). This is addressed in further detail in Chapters Eight and Nine.

The DOLWD also administers some delegated authorities of the Occupational Safety and Health Administration (OSHA), PL-91-596, 1970. Section 18 of the law allows states to obtain approval to assume responsibility for development and enforcement of federal occupational safety and health standards. The DOLWD has obtained approval from OSHA for administration of some of the federal OSHA standards (DOLWD 2016; OSHA 2016).

B. Federal

1. U.S. Environmental Protection Agency (EPA)

The EPA implements, administers, or oversees programs required by federal environmental laws and regulations. The implementation of some programs has been delegated to the states to safeguard the air, land, and water.

a. Air Quality Permits

The ADEC administers the federal Clean Air Act and the air quality program for the State of Alaska under a federally-approved state implementation plan (EPA 2016a).

b. Hazardous Waste (RCRA) Permits

The federal RCRA regulates the management of solid waste, hazardous waste, and underground storage tanks holding petroleum products or certain chemicals (40 CFR 264.175(b)–(c)). Regulations set the parameters for transporting, storing, and disposing of hazardous wastes and for designing and operating treatment, storage, and disposal facilities safely (40 CFR 264.193(b)). Regulations are enforced through inspections, monitoring of waste handlers, taking legal action for noncompliance, and providing compliance incentives and assistance (EPA 2016e).

Some states may receive authorization to administer parts of the program, which requires that state standards be at least as strict as federal standards. EPA administers the RCRA program in Alaska.

c. National Pollutant Discharge Elimination System (NPDES) Discharge Permit

ADEC administers this EPA program or APDES (*See* Section B). Permits specify the type and amount of pollutant, and include monitoring and reporting requirements, so that discharges do not harm water quality or human health.

d. Underground Injection Control (UIC) Class I and II Injection Well Permits

The EPA regulates injection wells used to dispose of fluid pumped into the well. Authorized as part of the federal Safe Drinking Water Act of 1974, EPA's UIC program protects underground sources of drinking water from being contaminated by the waste injected in the wells. Injection wells are categorized into five classes; Classes I and II are most common in the oil and gas industry. The EPA administers the program for Class I wells in Alaska, and authority for Class II oil and gas wells has been delegated to AOGCC (*See* Section D).

All injections falling into Class I must be authorized through EPA's UIC Class I program. Class I wells must operate under a permit that is valid for up to 10 years. Permits stipulate requirements such as siting, construction, operation, monitoring and testing, reporting and record keeping, and closure. Requirements differ for wells depending on whether they accept hazardous or non-hazardous wastes.

2. U.S. Army Corps of Engineers (USACE)

a. Section 10 and Section 404 Permits

The USACE has regulatory authority over construction, excavation, or deposition of materials in, over, or under navigable waters of the United States, or any work which would affect the course, location, condition, or capacity of those waters (Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 U.S.C. 401, et seq.; 33 U.S.C. 403) (COE 2014). Section 10 permits cover oil and gas activities, including exploration drilling from jack-up drill rigs and installation of production platforms.

Section 404 of the Clean Water Act regulates discharge of dredged and fill material into United States waters and wetlands. This program is administered by USACE, which is authorized to issue Section 404 permits for discharging dredge and fill materials.

Permits issued for specific projects are the basic type of permit issued. General permits (including programmatic, nationwide, and regional general permits) authorize activities that are minor and will result in minimal individual and cumulative adverse effects. General permits carry a standard set of stipulations and mitigation measures. Letters of permission, another type of project authorization, are used when the proposed project will not have significant individual or cumulative environmental impact, and appreciable opposition is not expected (COE 2017).

Section 404 and Section 10 permits follow a similar three-step review process: pre-application consultation (for major projects), formal project review, and decision making.

In making a final decision on whether to issue a permit, USACE considers conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and other factors judged important to the needs and welfare of the people (COE 2017).

The process for letters of permission is shorter: The proposal is coordinated with fish and wildlife agencies and adjacent property owners who might be affected by the project, but the public is not notified (COE 2017).

The ADEC reviews Section 404 and 10 permit applications for compliance with Alaska water quality standards. If the applications comply, DEC approves the permit.

Permits may also be reviewed by other agencies, such as the EPA, U. S. Fish and Wildlife Service, and National Marine Fisheries Service, to ensure compliance with the Endangered Species Act, the National Environmental Policy Act, and Essential Fish Habitat Provisions of the Magnuson-Stevens Act.

3. Pipeline and Hazardous Materials Safety Administration (PHMSA)

The federal Office of Pipeline Safety (OPS) in the Pipeline and Hazardous Materials Safety Administration (PHMSA), an agency of the US Department of Transportation, regulates movement of hazardous materials by pipeline (PHMSA 2016). Federal PHMSA inspectors review technical issues on hazardous liquid pipelines in Alaska. The 2006, PIPES Act requires hazardous liquid pipeline operators to develop integrity management programs for transmission pipelines (PHMSA 2006).

Jurisdictional authority over pipelines depends on many factors such as design, pipe diameter, product transported, or whether it meets state or federal designation, e.g., transmission line, gathering line, or distribution line, and other attributes as specified in regulations. Generally, the design, maintenance, and preservation of transmission pipelines transporting hydrocarbon products are under the authority and jurisdiction of the PHMSA with specific federal regulations for natural gas (49 CFR 192) and hazardous liquids (49 CFR 195). Both regulations prescribe the minimum requirements that all operators must follow to ensure the safety of their pipelines and piping systems. The regulations not only set requirements, but also provide guidance on preventive and mitigation measures, establish time frames for upgrades and repairs, development of integrity management programs, and incorporate other relevant information such as standards, incorporated by reference, developed by various industry consensus organizations.

4. National Marine Fisheries Service (NMFS)

The National Marine Fisheries Service (NMFS) is an office of the National Oceanic and Atmospheric Administration within the US Department of Commerce. NMFS has jurisdiction over dolphins, porpoises, whales, sea lions, seals, sea turtles in water, and over 130 endangered or threatened marine species (NOAA 2015), (NOAA 2016a). NMFS issues permits and authorizations under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) for activities that may result in the take or harassment of marine mammals (NOAA 2016b).

5. U.S. Fish and Wildlife Service (USFWS)

The USFWS is a federal agency within the Department of the Interior dedicated to conservation, protection, and management of fish, wildlife, and natural habitats. USFWS has management authority for migratory birds, threatened and endangered species, the national wildlife refuge system, aquatic resources, and landscape conservation (USFWS 2015). USFWS issues incidental take permits under the ESA for a limited set of marine mammals such as polar bears, walrus, and sea otters, as well as freshwater and terrestrial endangered species. Incidental take permits are required when non-Federal activities will result in take of threatened or endangered species (USFWS 2013).

6. U.S. Coast Guard

The US Coast Guard has authority to regulate oil pollution under 33 CFR §§ 153–157 in waters of the United States, and to make determinations on hazards to navigation under 33 CFR § 64.31.

The US Coast Guard may respond to discharges or threats of discharges of oil and hazardous substances into the navigable waters of the United States and promulgate certain pollution prevention regulations under 33 U.S.C. § 1321. The US Coast Guard regulates hazardous materials in commerce under U.S.C. Title 49. The US Coast Guard safeguards fisheries and marine protected resources by enforcing living natural resource authorities like the Magnuson-Stevens Fisheries Conservation and Management Act (16 U.S.C. § 1801), the Lacey Act (16 U.S.C. §§ 3371–3378), the Endangered Species Act (16 U.S.C. §§ 1531–1544), and the National Marine Sanctuaries Act (16 U.S.C. §§ 1431–1445).

C. Other Federal and State Regulatory Considerations

1. Regulation of Oil Spill Prevention and Response

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. § 9605), and § 311(c)(2) of the Clean Water Act, as amended (33 U.S.C. § 1321(c)(2)) require environmental protection from oil spills. CERCLA and the Clean Water Act require a National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR § 300; 33 U.S.C. § 1321(d)). Under the implementing regulations, the violator must plan to prevent and immediately respond to oil and hazardous substance spills and be financially liable for any spill cleanup. If the pre-designated Federal On-Scene Coordinator (FOSC) determines the response is neither timely nor adequate, the federal government will respond to the spill, and then seek to recover cleanup costs from the responsible party.

The Oil Pollution Act of 1990 (OPA 90) requires the development of facility and tank vessel response plans and an area-level planning and coordination structure to coordinate federal, regional, and local government planning efforts with the industry. The OPA 90 amended the Clean Water Act (§ 311(j)(4); 33 U.S.C. § 1231(j)) and established regional citizen advisory councils and area contingency plans as the main parts of the national response planning structure.

The Alaska Regional Response Team is an advisory board to the FOSC. It provides processes for participation by federal, state and local governmental agencies to participate in response to pollution incidents (ARRT 2014). The Unified Plan is the area contingency plan for Alaska. Since Alaska is large and geographically diverse, federal agencies also prepare subarea contingency plans (ADEC 2010).

2. Alaska National Interest Lands Conservation Act (ANILCA)

The Alaska National Interest Lands Conservation Act provides for “the national interest in the scenic, natural, cultural and environmental values on the public lands in Alaska”. At the same time the Act provides opportunities for rural residents engaged in a subsistence way of life the on these lands to continue in that subsistence way of life on public land.

3. Native Allotments

Lessees must comply with applicable federal law concerning Native allotments. Activities proposed in a plan of operations must not unreasonably diminish the use and enjoyment of lands within a Native allotment. Before entering lands subject to a pending or approved Native allotment, lessees must contact the Bureau of Indian Affairs and the Bureau of Land Management and obtain approval to enter.

D. Local Governmental Powers

1. North Slope Borough (NSB)

Under the authority of Title 29 of the Alaska Statutes, the NSB is responsible for planning and zoning through the implementation of Title 19 of the North Slope Borough Code. Title 19 is administered through the NSB permitting program and aims to ensure future growth according to values of borough residents and secure benefits address negative impacts of development (NSB 2014). All lessees and development activities must be consistent with the management policies of Title 19 and the NSB Comprehensive Plan.

Title 19 of the Borough Code sets out the land use regulations and created a Department of Planning and Community Services. The department is responsible for administering the borough's planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use, and provides review and comment on development issues borough-wide. Title 19 also sets out the zoning districts for the NSB. The Resource Development (RD) district is designed and intended to address cumulative impacts of large scale development, and to offer developers quick, inexpensive, predictable permit approvals. The purpose of the RD district is to accommodate large scale resource extraction. Prudhoe Bay, Milne Point, Duck Island and Kuparuk River are included in the RD district as preexisting development. Other reservoirs that are located in different geologic strata directly under these existing areas are also included in the RD district.

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Chapter Eight: Reasonably Forseeable Effects of Leasing and Subsequent Activity

Contents

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Decades of oil and gas activities in the Sale Area has had a range of effects on the environment, fish and wildlife, subsistence uses, cultural resources, and other uses. As effects are understood, measures are taken to prevent and mitigate negative effects reasonably foreseen to be created by oil and gas operations. The Division of Oil and Gas (DO&G) has cooperatively developed general mitigation measures that lessees must follow to minimize pollution and habitat degradation, and disturbance to fish and wildlife species, subsistence users, and communities within or adjacent to the Sale Area. Further, post-disposal authorizations may be subject to additional project-specific and site-specific mitigation measures that the commissioner deems necessary to protect the state's interest. Despite these protective measures, impacts may occur. In accordance with AS 38.05.035(g), the reasonably foreseeable cumulative impacts of post-disposal oil and gas activities and brief summaries of measures to mitigate those impacts are presented in this chapter. See Chapter Nine for a complete list of the mitigation measures for the Sale Area.

Alaska statutes specify that speculation about possible future effects is not required (AS 38.05.035(h)). However, many studies, much of which are applicable to the Sale Area, are available on the effects of oil and gas development for arctic and northern habitats, fish, and wildlife. Although the Sale Area may differ from these areas in some respects, it shares much in common with these environments, thus much of this body of knowledge is applicable to the Sale Area. As a result, these effects are considered and discussed below as required by AS 38.05.035(g).

A. Introduction

Under AS 38.05.035(g)(1)(B)(ix) and (vi), the director is required to consider and discuss facts material to the reasonably foreseeable fiscal effects of the lease sale on the state and affected municipalities and communities, and the reasonably foreseeable cumulative effects of post-disposal oil and gas activities on the Sale Area including: effects on subsistence uses; fish and wildlife habitat and populations and their uses; and historic and cultural resources. The director must also consider and discuss facts material to the reasonably foreseeable effects of exploration, development, production and transportation of oil and gas, or gas only, on municipalities and communities within or adjacent to the lease sale area under AS 38.05.035(g)(1)(B)(x).

Until oil and gas leases are issued and discoveries are made, the director cannot predict if or when post-disposal oil and gas activities might occur, or the type, location, duration, or level of those potential activities. Strategies and methods used to explore for, develop, produce, and transport petroleum resources will vary, depending on factors unique to the individual area, lessee, operator, or discovery. If a commercially viable deposit is found, development will require construction of one or more drill sites. If commercial quantities of oil, gas, or both are located, construction of pipelines would be likely, and other production and transportation facilities would be necessary. New roads may be required, and machinery, laborers, and housing would be transported to and located on the project sites.

The lease sale itself is not expected to have any effects other than to provide initial revenue to the state. Post-disposal oil and gas activities could affect fish and wildlife and their uses, terrestrial, freshwater, and marine habitats in the Sale Area, and the uses of these resources. Post-disposal activities could include seismic surveys related to exploration, development, and production of petroleum resources; collection of environmental, cultural and other data; excavation of material sites; construction and use of support facilities such as gravel pads, staging areas, roads, airstrips, pipelines and housing, processing facilities, and flow stations; transportation of machinery and labor to the leased area; and construction of drill sites and ongoing production activities.

In addition to the mitigation measures in Chapter Nine, all post-disposal activities are subject to local, state, and federal statutes, regulations, and ordinances, some of which are listed as other regulatory requirements in this chapter and some of which are discussed in Chapter Seven. Additional project-specific and site-specific mitigation measures may be required by other regulatory agencies, in response to public comments received during review of the proposed activity or as deemed necessary. Mitigation measures listed in Chapter Nine may also be changed or removed, and additional measures may be added through the Call for New Information and supplement process described in Chapter Two.

The scope of this administrative review and preliminary finding addresses only the reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal of state land (AS 38.05.035(e)(1)(A)).

B. Phases of Oil and Gas Development

There are several different phases of oil and gas activities: 1) exploration, 2) development, 3) production, and 4) transportation. While not all post-disposal oil and gas activities are routine, there are some oil and gas activities that are reasonably foreseeable because they are commonly undertaken during exploration, development, production, and transportation, regardless of the project. Routine post-disposal activities, such as seismic surveys, drilling, and construction, have associated impacts or potential impacts.

Oil and gas activities include those direct and indirect activities that have occurred in the past, are presently occurring, or are likely to occur in the future. Petroleum-related activities include such major undertakings as conducting seismic operations, constructing ice roads and snow trails for transporting equipment and supplies for winter drilling of exploration wells, drilling exploration and delineation wells, constructing gravel pads and roads, drilling production and service wells, installing pipelines, and constructing oil and gas processing facilities. The activities likely to have the greatest effects vary by resource.

Oil and gas exploration, development, production, and transportation activities in the Sale Area may cause potentially negative changes in the arctic environment. From the initial exploration and seismic phase of the extraction and field operations to the transportation of the product, oil and gas activities involve construction of dedicated infrastructure that can change the quality of the surrounding environment and modify habitat for terrestrial and marine wildlife.

Common industrial facilities associated with the oil and gas industry in the Sale Area include: drill sites, well pads, ice pads, production pads and injection pads, wells (such as exploratory, development, production and waste disposal), processing facilities, above ground oil storage tanks, building modules, facility oil piping, crude oil transmission pipelines, drilling mud plant, flow lines and pipelines, maintenance complex, emergency response center, warehouse facilities and seismic vibrators (thumper truck), transportation, gravel roads, ice roads, airports, bridges, power plants, refineries, residential centers, and solid waste disposal units (Trammell et al. 2015).

1. Exploration

The purpose of the exploration phase is to search for reservoirs of oil and gas. Oil and gas resource exploration begins with gathering information about the petroleum potential of an area by examining the surface and subsurface geology, researching data from existing wells, performing environmental assessments, conducting geophysical surveys, and drilling exploratory wells. The surface analysis includes the study of surface topography or the natural surface features, and near-surface structures revealed by examining and mapping nearby exposed rock layers. Geophysical surveys, primarily seismic, help reveal the characteristics of the subsurface geology, and normally precede exploratory drilling. Although geophysical exploration and exploration drilling are activities that could result in potential effects to the Sale Area, onshore exploration on the North Slope predominately occurs in the winter to mitigate effects on the tundra and wildlife.

Common activities undertaken during the exploration phase includes aerial and geophysical surveys used to define prospects, geological studies, core testing, and exploratory drilling. Exploration wells may be used to drill in unproven areas, for field extension step outs or delineation wells used in unproven areas to increased proven limits of a field, or to conduct deep tests within a producing area to unproven deeper zones.

2. Development

The purpose of the development phase is to gather, examine, and analyze geologic and other data pertaining to newly discovered reservoirs gained in exploration to plan how to produce the maximize recovery of hydrocarbons from a reservoir. Common activities include drilling development and disposal wells, construction of roads and pads, and installation of pipelines and production facilities. Development wells are drilled in proven areas of a field to prepare for production operations. Some production operations overlap with development operations. Drilling occurs after initial discovery of hydrocarbons in a reservoir and several wells may be required.

3. Production

The production phase is the process of bringing well fluids to the surface and preparing them for transport to the processing plant or refinery. The fluids undergo operations to be purified, measured, tested, and transported. Pumping, storage, handling, and processing are typical production processes. The final project parameters will depend on the surface location, size, depth, and geology of a specific commercial discovery. Production also refers to the amount of oil or gas produced in a given period (Chaudhuri 2016).

A central processing facility usually serves as the operational center for long-term production activities in a large North Slope oil or gas field. The central processing facility typically is located on the largest and most central, or initial, development pad. Equipment at the central processing facility is used to separate the materials that are produced from the wells (oil, natural gas, and water) on the pad. The central processing facility also processes produced oil and gas from any smaller, outlying satellite pads. Produced oil is filtered to remove sand and processed to remove water and gas before being piped through a sales meter and into the sales-oil pipeline system—Trans-Alaska Pipeline System (TAPS), or a feeder line for TAPS. Associated gas is usually processed to remove liquids and impurities, compressed, and reinjected into the reservoir through gas injection wells or sent through a pipeline to another field or area for enhancing recovery or fuel gas. In the case of a commercial, non-associated gas operation, gas is processed and sent through a compressor then directly into a gas pipeline to market. Water can be processed, chemically-treated, and reinjected into the reservoir for pressure maintenance (BLM 2013).

4. Transportation

The transportation phase encompasses the movement of oil or gas from one place or another by some means, such as pipeline or tanker. A regional oil transportation system for the North Slope oil fields was established in 1977 upon completion of the TAPS. Oil is transported some 800 miles through a 48-inch pipeline to the ice-free port of Valdez, Alaska. From the storage and marine loading terminal at Valdez, oil is loaded onto tankers and transported to U.S. and foreign markets. The throughput capacity of the TAPS plays a significant role in North Slope development. Without this vital transportation system, continued production from the North Slope is unlikely.

A network of gathering and common carrier pipelines moves sales quality oil from producing fields on the North Slope to TAPS. Another network of pipelines moves liquids and gases throughout a producing field for processing, reinjecting, and transportation to market. All development projects in the Sale Area assume that TAPS will continue to operate and carry North Slope oil production for decades into the future.

C. Post-Disposal Oil and Gas Activities

Oil and gas activities associated with the post-disposal phases include geotechnical and geophysical surveys; exploratory and development drilling operations; construction of pads, facilities, and other infrastructure; and production and transportation have the potential to affect resources in various ways. Acoustic environments, soils, vegetation, hydrology, water resources, and air quality may be impacted by post-disposal oil and gas activities. Direct and indirect effects of oil and gas activities can disturb or displace wildlife and impact habitats through alteration, fragmentation, or loss.

Disturbance resulting from post-disposal oil and gas activities will depend on the type, location, and intensity of the activity. Habitat disturbance and alteration in the Sale Area will result from seismic activities, drilling wells, constructing gravel pads, roads, airstrips, support and processing facilities, and pipelines. Noise in the environment occurs at differing levels, frequencies, and durations and from many sources, some of which are natural. Noise arising from oil and gas activities can contribute disturbance above background levels. Noise may be generated in all phases of exploration, development, production, and transportation (AMAP 2013). The facilities required to support oil and gas development may have numerous effects. As infrastructure expands from a development, it may begin to fragment the surrounding habitats. Fragmentation has the potential to disrupt migrations, displace breeding grounds, and alter the relationships between predators and prey. Governmental authorities regulate oil and gas activities to minimize effects the environment and mitigation measures are part of the lease document which reduce or eliminate future effects on oil and gas leases.

1. Seismic

Seismic survey work is an integral part of exploration for oil and gas fields. Seismic data is collected from surface-induced seismic pulse to image subsurface formations with sensors collecting the data as seismic shock waves bounce off formations. The shock waves are created by vibrator trucks or small explosives along predetermined lines. Seismic surveys are typically conducted in two-dimensional (2D) or three-dimensional (3D) surveys. Both survey types are useful for evaluating a prospect. The 2D seismic survey collected over grid lines along easy access points. A 3D seismic survey is similar to 2D acquisition with more sensors collecting more data (Rigzone 2018).

Seismic may be used during all phases of oil and gas development, including pre-disposal, to locate and produce oil and gas from new and existing developments. Companies may elect to license existing data and reprocess the data without conducting a seismic survey. Other companies may acquire data through commissioning their own program. It is also common for seismic contractors to conduct their own seismic surveys on unleased land or on behalf of a lessee. Geophysical exploration by means of seismic surveys informs the analysis of a play, where a company will conduct exploratory drilling, further mapping of a producing field, and evaluating new intervals throughout the development process.

Seismic data has been collected in the Sale Area for decades. Continuing acquisition of seismic data is undertaken to capture higher resolution data through finer seismic grid spacing or grid pattern, and to acquire additional seismic data using advanced techniques over an existing discovery. Reflection seismic data are used to image the layering and geometries of the subsurface and detect changes of lithology and fluid properties. These images when combined with current well information can be used to better image and define the limits of the discovered hydrocarbon pool and to help design efficient development drilling and enhance the ability to successfully identify high-grade drilling targets.

Several advanced seismic techniques can be used to image producing fields. Lands already in production are sometimes subjected to additional 3D seismic to monitor changing reservoir properties resulting from production. This seismic technique is sometimes called 4D seismic because, though it would be conducted like 3D, repetition adds the dimension of time. This technique can also use permanent static geophones to ensure repeatability and coupling. Additional geophysical techniques can be used to gather information specifically about very near surface geology, usually to identify drilling hazards. They include high-resolution shallow seismic, side-scan sonar, fathometer recordings and shallow coring programs. High-resolution shallow seismic surveys are specifically designed to image the bottom of a water body and very shallow geology. They employ a lower energy seismic source and a shorter cable than surveys targeting deeper oil and gas potential (U. S. Senate 2011).

Collection of seismic reflection data in aquatic areas (ocean, lakes, bays, and lagoons) is commonly accomplished using vessels of varying size during ice-free periods. Typically, one or more air guns are used as a sound source. Air guns, which are deployed behind the seismic vessel, generate a seismic signal by creating a sharp air bubble pulse in the water at intervals about once every 10 seconds. Marine receivers are composed of piezoelectric hydrophones that are contained in long, sealed tubes. Receiver systems can be deployed either as streamers that are towed behind a vessel or as cables that are laid directly on the seabed or lake bottom. Seismic streamers can be several miles in length and are generally used in deeper water where maneuverability is not an issue. Seismic cables (on-bottom cables) or nodal cableless systems are used in shallower water or in waterbodies where ice has not reached the bottom. Both receiver systems contain numerous hydrophones that measure faint pressure signals returning from reflections in the subsurface. These seismic data acquisition techniques are generally intended for imaging subsurface depths of several hundred feet to six miles. Surveys designed for shallower subsurface depths and higher resolution generally employ lower sound levels and shorter hydrophone systems (Asseev et al. 2016).

When a lessee or contractor seeks a permit to perform a seismic survey of any variety in the Sale Area, a miscellaneous land use permit (MLUP) is required through the Alaska Department of Natural Resources (DNR). Seismic surveys can be performed at any phase of oil and gas development and whether a party holds interest in the subject leases or not. Through the MLUP review, DNR will evaluate the project plan and consider other agencies' input and authorities to assess potential impacts of the project. Potential project impacts are mitigated through mitigation measures and, possibly, lease stipulations.

2. Drilling

A lease gives a lessee the right to use the leased areas for exploration, development, production, and transportation activities. However, it does not authorize operations or any specific activities to be conducted on the lease. Before initiating any drilling, a lease plan of operation application must be submitted to DNR for review and approval. The application is reviewed for legal compliance by DNR and other state, federal, and local government entities. DNR evaluates foreseeable effects of the proposed application operations, assesses lease mitigation measures, and determine the need for lease stipulations to protect resources and the best interest of the state. An application may require conditions for approval before final approval of a plan of operations. All exploratory, delineation, and development well drilling is subject to plan of operation approval. Proposed wells within units must also be documented and approved through a plan of exploration or development with DO&G before drilling operations may be conducted.

a. Exploratory Drilling

Exploration drilling, which proceeds only after obtaining the appropriate permits, is the only way to determine whether a prospect contains commercial quantities of oil or gas, and aids in determining whether to proceed to the development phase. Drilling operations collect well logs, core samples, cuttings, and a variety of other data. A well log is a record of one or more physical measurements as a function of depth in a borehole and is achieved by lowering measuring instruments into the well bore. Well logs can also be recorded while drilling. Cores may be cut at various intervals so that geologists and engineers can examine the sequences of rock that are being drilled (Chaudhuri 2016).

The drill site is selected to provide access to the prospect and, if possible, is located to minimize the surface area that may have to be cleared. Sometimes temporary roads must be built to the area. Nonpermanent roads are constructed of ice, with permanent roads being constructed of sand and gravel placed on a liner above undisturbed ground. Construction of support facilities such as production pads, roads, and pipelines may be required. A typical drill pad is made of ice or sand and gravel placed over a liner. The pad supports the drill rig, which is brought in and assembled at the site, a fuel storage area if necessary, and a camp for workers. If possible, an operator will use nearby existing facilities for housing and feeding its crew. If facilities are not available, a temporary camp of trailers on skids may be placed on the pad (Chaudhuri 2016).

To define the limits of reservoirs after a discovery is made, several delineation wells may be drilled before making a commitment to full project development. Additional delineation wells surrounding the discovery well would likely be planned for the following winter seasons and would require new ice pads. Delineation-well drilling would be coordinated with any existing 3D seismic surveys (Duplantis 2016). Upon making a discovery and sufficiently delineating a reservoir, production of the resource and development of the field will take place.

b. Production drilling

Production, or development, drilling will be conducted from gravel pads with several wells typically drilled from that pad depending on development plans for the field. The production drilling process is similar to exploration drilling in that drilling fluid is used to balance pressure to prevent blow-outs, remove rock fragment, and cool the drill bit. During the process of drilling the well, well casing is placed in the hole for stabilization and to prevent caving. Once drilling is completed, testing is conducted to determine where to perforate zones and begin stimulation of those zone to enhance flow rates. Production tubing is installed in the well to carry liquids and gas to the surface and a “Christmas tree” is installed at the surface to control flow from the well (EPA 2018). This process occurs for each production well drilled on the pad and other pads in the field.

Directional drilling is used to extend the length of the reservoir that is penetrated by the well (U. S. Senate 2011). Exploration wells within the Sale Area may be directionally drilled because of a lack of suitable surface locations directly overlying exploration targets. The drilling technique used is controlled to direct the bore hole to reach a particular part of the reservoir. Directional drilling technology enables the driller to steer the drill stem and bit to a desired bottom hole location, sometimes miles away from the surface location of the rig. Directional wells initially are drilled straight down to a predetermined depth and then gradually curved at one or more different points to penetrate one or more given target reservoirs (Duplantis 2016). Directional drilling allows multiple production and injection wells to be drilled from a single surface location such as a gravel pad or offshore production platform, thus minimizing cost and the surface impact of oil and gas drilling, production, and transportation facilities. It can also be used to reach a target located beneath an environmentally-sensitive area and may offer the most economical way to develop offshore oil fields from onshore facilities. Extended reach drilling is used to access reservoirs that are remote, up to six miles, from the drilling location. These techniques allow for drilling into reservoirs where it is not possible to place the drilling rig over the reservoir (U. S. Senate 2011).

In addition to production wells, other wells are drilled to inject water or gas into the field to maximize oil recovery. These wells generally are referred to as service, or injection, wells. Numerous injection wells are required for waterflood programs, which are used routinely throughout the production cycle to maintain reservoir pressure. Application of horizontal well technology can reduce the number of production wells required to drain a pool and reduce the number of drilling pads and their sizes. (U. S. Senate 2011).

c. Drilling and Production Discharges

Industrial, specialty, and potentially hazardous chemical products are used at all stages of oil and gas production. The main categories are drilling fluids, production chemicals, and injection chemicals.

i. Drilling Fluids, Drilling Mud and Rock Cuttings

Drilling fluids are necessary for most new well drilling operations. They provide a barrier for well control, help to remove cuttings from the well bore as they are produced, maintain pressure on the formation, and maintain formation stability among other functions (IPIECA 2009). The Alaska Oil and Gas Conservation Commission (AOGCC) requires drilling fluid systems to meet its requirements unless it determines otherwise (20 AAC 25.033).

Once a rig is in place and drilling has begun, waste discharges could include drill cuttings, spent drilling fluids, cuttings from water-based well intervals, domestic wastewater, excess cement, brine water from desalination units, uncontaminated deck drainage, non-contact cooling water, uncontaminated ballast water, bilge water, and blowout preventer fluid (UNEPIE 2007). However, Section 402(a) of the Clean Water Act prohibits the discharge of produced water and drilling wastes into the marine environment from oil and gas production facilities that are either onshore or in coastal waters. On the North Slope, nearly all exploration and production wastes are injected into underground waste wells (Veil 2001). Generally, all wastewater, spent fluids, and chemicals would be disposed of in injection wells approved by the the US Environmental Protection Agency (EPA), the AOGCC, or Alaska Department of Environmental Conservation (ADEC), depending upon waste characterization.

Rock cuttings, broken bits for solid material removed from a borehole during drilling, are typically trucked to one of several grind-and-inject facilities in the Sale Area. For some operations, solid waste disposal sites are authorized near drilling sites by ADEC for short-term waste storage before being transported for disposal.

ii. Produced Water

Produced water is water that comes from an oil and gas reservoir to the surface through a production well with hydrocarbons. It is the largest waste stream from the production phase of conventional oil and gas wells. The produced water volume increases over the economic lifetime of a producing field and may be up to 95 percent of the total volume produced by the end of the field’s production history. Produced water contains formation water, injection water, and other chemical additives such as hydrate inhibitors, emulsion breakers, flocculants, coagulants, defoaming agents, scale and corrosion inhibitors bactericides and other substances (AMAP 2013 citing to Lee et al. 2005, Tibbets et al. 1992, and Roe Utvik 1999)

Produced water on the North Slope is reinjected into reservoirs for waterflooding and pressure maintenance or injected through waste water injection wells to shallow reservoirs. The produced water is not typically treated and released into waterbodies in the Sale Area. As a field matures, measures are taken to treat produced water before reinjection into the reservoir to eliminate bacteria and chemical additives. When produced water can no longer be treated and reinjected, the alternative in the Sale Area is disposal. The ADEC and AOGCC authorize disposal of produced water. More information can be found in Chapter Seven outlining government authorities to regulate waste water disposal and produced water injection.

3. Road and Facility Construction

a. Facilities

After a commercial discovery of oil or gas has been confirmed by delineation wells and seismic surveys, several construction activities are required to develop a permanent production operation. A production operation complex would, at a minimum, contain a production pad that could potentially support dozens of wells and contain a large central processing facility for an oil field or a combined central processing and gas compressor facility. In addition, a production complex typically would include an airstrip, camp facilities, and storage yard. The production operation also would include feeder lines, regional pipelines, a booster pump for oil or additional compression stations for gas, a high-pressure gas trunk line, a gas conditioning facility, and an oil-sale pipeline to transport the resource to market. Depending on the size of the field or the presence of nearby fields, the production operation complex may also include outlying oil production pads. The smaller satellite pads would serve primarily as a well pad designed to produce hydrocarbons from a smaller prospect located beyond the reach of wells drilled from the main production pad or central processing facility. A gathering system to the central processing facility or central processing or gas compressor facility, and a road, or in some cases an airstrip instead of a road, would be needed to access the satellite pad (NRC 2003).

Similar to drilling operations, all construction activities on a lease are subject to a plan of operations approval by the DNR. The construction or maintenance of major production facilities also require plans of exploration or development.

b. Roads

Development and operation of oil and gas facilities in the Sale Area may require access across the tundra, off pads, or on gravel or ice roads. Such access could be necessary to respond to spills or other emergencies; conduct training to respond to potential spills; conduct pipeline inspection, maintenance, and repair; facilitate ice road construction; or transport equipment and supplies to oil developments not connected to the interconnected North Slope gravel road network. Vehicles would conduct these activities from the nearest production or processing facility pads or gravel or ice roads (NRC 2003).

Construction of ice roads begins by compacting snow with wheeled front-end loaders and water trucks. If prepacking is authorized, it is done with low-ground-pressure vehicles or various tracked rigs. Typically, ice roads are designed to be a minimum of six inches thick and 25–35 feet wide, and can be several miles long. New ice-road construction methods, such as using aggregate chips shaved from frozen lakes, substantially decrease both water demands and construction time. For example, under good (very cold) conditions, an ice-road-buildup rate using only liquid water is 1.5 inches per day, whereas using aggregate chips could increase the buildup rate to 4.5 inches per day, with equivalent reduction in the volume of water required. Similar flooding and composite (aggregate chip) methods are employed to construct ice bridges over rivers and lakes. Floating ice bridges are used to cross deep rivers, such as the Colville River (NRC 2003).

Snow-packed trails are also constructed and approved for use by low-ground-pressure vehicles and can be used for moving equipment, supplies, personnel accommodations, and drill rigs capable of disassembly to components small enough for transport on such vehicles. When the tundra is open for prepacking, two vehicles with the least amount of ground pressure (1.2–2.0 psi) are run side-by-side and follow GPS coordinates along the entire length of the approved snow trail route. After several days of snow capture along the new trail, these vehicles drive the route again to complete the snow compaction process and open the trail for use by other low-ground-pressure vehicles that exert less than four psi of pressure on the ground. Due to winter-travel time constraints, costs, and extended distances from current infrastructure to new exploration areas in the Sale Area, frequency in the construction and use of snow-packed trails is expected to increase (NRC 2003).

Construction of gravel pads may be used for well sites, production and support facilities, roads, and an airstrip. Gravel is the preferred material for development pad construction. The development area must be level, stable, and elevated above the wet tundra surface. Because the tundra surface is unstable and, especially in the coastal plain, subject to flooding in summer and ice-jacking forces in winter, pad surfaces are designed to be at least five feet above the tundra surface (NRC 2003).

For the most part, authorizations relating to road construction for temporary use (ice roads and snow-packed trails) are issued through land use permits by DNR's Division of Mining Land and Water (DMLW). The only exception is temporary use roads for seismic surveying will be authorized through a MLUP issued by the DNR's DO&G. The DO&G will authorize permanent roads (gravel) on leases in the Sale Area through a plan of operations. The authorizations evaluate potential impacts and seek agency review to address and mitigate potential impacts from construction.

4. Transportation by Pipeline

The actual locations of new pipelines in the Sale Area would depend on the location and sequence of commercial-sized discoveries. At present, there is no accurate way of predicting where or when new commercial fields would be discovered and developed. It is possible that some fields discovered by different companies would be shut in and not produced until an agreement was reached to share the costs of constructing a pipeline system with developers of other discoveries.

The diameters and lengths of new pipelines in the Sale Area would depend on the characteristics of new fields. Generally, infield oil pipelines, such as flowlines or gathering lines carry oil, gas, and water from wellhead manifolds to central processing facilities. Return lines containing gas or water would carry these substances back to injection wells on production pads. Infield flowlines would be relatively small, between four and ten inches in diameter.

Typically, oil pipeline routes are laid out in straight-line segments and are elevated at least seven feet above the tundra on vertical support members (VSM). On the North Slope, this installation method is preferred over buried pipelines, because aboveground pipelines take less time to construct, cause less disruption to the land during installation, are easier to monitor and repair, and provide more flexibility for later modifications such as adding new pipelines (AMAP 2013).

Within DNR, the DO&G and State Pipeline Coordinator (SPC) each have authority to approve operation and construction of pipelines in the Sale Area. The DO&G will approve on-lease gathering lines through a plan of operations approval and SPC will issue leases of state land through a right-of-way process. SPC also coordinates the oversight of all construction and operation phase for sales pipelines or pipelines transporting products after metering has occurred. Chapter Six provides methods most likely to be used to transport oil or gas from the lease area in addition to the merits and relative risks for each method.

5. Oil Spills and Gas Releases

Oil spills and natural gas releases can occur on pads within the Sale Area when exploration drilling or development and production is occurring. Spills and releases can also occur during the course of transportation on pads, between facilities, or during delivery to TAPS. Chapter Six and Seven provide information on regulatory authorities for prevention and response, process for spill or release containment, cleanup, and response training. Chapter Nine included mitigation measures for spill and release prevention.

a. Spills on Tundra

Historically, on the North Slope, most oil spills occur on land, and in areas of containment—on pads or in facilities designed to contain a spill. However, there is a risk of spills onto the tundra. Because much of the exploration phase is being done in the winter, containment and remediation would be more effective.

However, with the onset of development and production, operations are continually conduced which is a risk or spills on ice and tundra. Onshore oil spills behave more predictably and are easier to control than spills into water because, generally, spills on land occur in a more stable environment and move more slowly to affect a smaller area. If the spill moves, it will collect in depressions or water courses. But if the volume is large and the duration of the spill is long enough, it can move down the water course to the nearest water bodies (Owens 2000).

There are specific challenges with the North Slope tundra where permafrost and wetlands are prevalent. Gravity will cause oil spilled on land to migrate down through the soil and, as it descends, to also spread. If the spill substance is less dense than water then, once it reaches a water aquifer, it will form a lens on top and spread laterally. As it encounters flowing water, soluble components may dissolve and form a plume. If the spill substance is heavier than water it will displace water and continue migrating until it encounters an impermeable stratum (Abriola 1989).

As with marine spills, the grade of oil spilled will affect how it weathers. Light crudes may infiltrate soil or sediments but may also evaporate rapidly. The porosity and permeability of surface materials will determine how other oil types penetrate the surface (Owens 2000). Spills may flow directly into freshwater or may migrate to freshwater. Once a spill arrives at a water body, the primary processes influencing the behavior of the spilled oil are spreading and drift, emulsion and dispersion, evaporation, dissolution, sorption, sedimentation, sinking, and photo and biodegradation. Freshwater affects these processes differently than does saltwater in that freshwater is less dense, has higher sediment loads, and has more turbulence, which tends to mix oil into the water column. Oil is more likely to sink in less dense water as well. Factors influencing the fate and effects of oil in freshwater are the currents, shoreline complexity, nutrient concentrations, sediment loads, water temperatures, past exposure, and time of year (API 1999).

The effects of a spill in freshwater can be both direct and indirect and the magnitude of either depends most importantly on the type of product spilled, the flow dynamics in the particular environment, what species are present, the climate, and the spill response. Immediate effects on aquatic organisms are from being coated or entrapped. Acute toxicity can result from dissolution of the spilled substance, which can lead to membrane damage and systemic toxicity, though post-spill field observations suggest that toxic effects tend to be less extensive than physical ones. In general, the chance of an organism being affected by a spill depends on whether it directly encounters the spill before the spill has had a chance to weather or dissipate (API 1999).

b. Spills into Water

A very small portion of the Sale Area is offshore, so an offshore spill on water or ice in the Sale Area is highly unlikely. However, the risks are worth describing considering the numerous rivers, streams, lakes, and other small waterbodies in the Sale Area. Oil is typically less dense than water so it floats on the surface of the water when spilled and disperses across the surface. The location and fate of oil on a shoreline depend on whether it is a subsurface or surface spill, the spill trajectory, the porosity and physical nature of the shoreline, and the characteristics of the oil spilled (Wiens 2013). The effect of a spill also depends on the toxicity, viscosity and amount of oil, the sensitivity of contacted organisms, and the length of contact time (IPIECA 2008).

For any nearshore or offshore development, weather and wave conditions, and the amount of suspended sediment in the water will determine the fate of the oil in the water. As soon as oil hits water, it begins to transform, or weather, as it is moved by wind, waves, and currents (Wiens 2013). The National Oceanic and Atmospheric Administration’s Alaska ShoreZone project has mapped the Alaskan coast and cataloged geomorphic and biological resources (NOAA 2017).

The fate of oil and its behavior in water and in the water column have been studied for decades. When oil is spilled into the sea several physical and chemical changes begin to take place as it begins to spread. The rate of dispersion depends largely on the type of oil and the sea state in which it is spilled. With low viscosity oils or thin oil, breaking waves tend to disperse and break down the contaminant quickly. The dispersed oil mixes in increasing volumes of sea water, which reduces its concentration. The increased surface area promotes biodegradation, dissolution, and sedimentation, and the speed at which the oil spreads depends on its viscosity. Heavier crudes or oils with high viscosity, persist longer in the environment than lighter crudes (Wiens 2013).

For a spill occurs on ice, there are few ways the spill would travel. Generally, the spread of oil spilled on ice is viscosity-dependent with cold temperature slowing the spreading rate. Surface roughness and occurrence of snow reduce spreading rate and make the spilled oil more likely to cause pooling. If the oil spreads, it can transition underneath solid ice or within the ice pack. In these cases, it has been determined through testing that even large spills will eventually be contained with a relatively short distance from a spill source. Exceptions to these observations are areas of high ice drift or close vicinity to open water where the oil movement is subject to currents and wind movement (NRC 2014).

c. Gas Releases

Natural gas is primarily composed of methane (CH_4) and ethane (C_2H_6), which make up 85–90 percent of the volume of the mixture. Methane is a colorless, odorless, and tasteless gas. The EPA identified methane as a greenhouse gas in new source performance standards adopted on August 2, 2016, but it has since proposed to stay portions of that rule (EPA 2016a). Methane is not toxic in the atmosphere, but it is classified as a simple asphyxiate, possessing an inhalation hazard (AMAP 2013).

There are three general types of potential gas releases: loss of well control at production areas, ruptured gas pipelines, and gas processing facilities. A release from a well is estimated to last one day and release 10 million cubic feet of natural gas. A release from a ruptured transmission pipeline or gas processing facility is estimated to release 20 million cubic feet over a few hours. These releases would be localized to the area adjacent to the release site. Thermal effects are estimated to be within 500 meters of the ignition source (AMAP 2013).

Natural gas releases pose a primarily acute hazard. Hazards associated with natural gas are predominantly flammable in nature. If an ignition source exists, a release of gas can result in an immediate fire or explosion near the point of the release. This hazard is reduced over a relatively short period after the release ends as the gas disperses. If the vapors accumulate in a processing facility or compressor station, then the hazard may remain longer.

D. Reasonably Foreseeable Cumulative Effects to Air and Water

1. Reasonably Foreseeable Cumulative Effects on Air Quality

The types and relative amounts of air pollutants generated by oil and gas operations vary according to the phase of activity (i.e., exploration, development, or production). During the exploration phase, air pollutant emissions are mainly made up of nitrogen oxides, carbon monoxide, particulate matter, and sulfur dioxide. During the development phase, emissions are similar to those used in the exploration, but with less carbon monoxide, particulate matter, and sulfur dioxide. During the production phase, emissions mainly contain nitrogen oxides, carbon monoxide, and particulate matter. In addition to these pollutants, hazardous air pollutants may also be released. Benzene, toluene, ethylbenzene, and xylenes are common hazardous air pollutants associated with volatilization of oil and gas resources. Depending on specific atmospheric environments, hydrogen sulfide may also be found in oil (BLM 2012).

The air quality throughout the Sale Area is generally good as a result of few pollution sources and good dispersion created by frequent winds and neutral to unstable conditions in the lower atmosphere. Windblown dust tends to occur more in the summer months as sandbars dry along the riverbeds in the Colville River delta, resulting in temporary increases in concentrations of particulate matter. Emission sources in and adjacent to the Sale Area consist of oil and gas production facilities including Kuparuk, Milne Point, Prudhoe Bay, Northstar, Endicott, and Alpine fields. Emissions sources at these field production and drilling sites include gas-fired turbines and heaters, incinerators and flaring, diesel-fired power generators, storage tanks, fugitive hydrocarbon emissions, and mobile sources such as vehicle traffic and aircraft (ADEC 2016b).

a. Potential Effects on Air Quality

The main air pollutants of concern in Alaska are fine and coarse particulate matter categories (PM 2.5 and PM 10), followed by carbon monoxide, lead, ozone, sulfur dioxide, and nitrogen dioxide (ADEC 2012). Combustion sources are the primary sources of fine particulates. The EPA requires an annual emissions inventory report for sources with potential emissions at or above 2,500 tons per year of sulfur oxide, nitrogen oxide, or carbon monoxide, and for annual emission of 250 tons for volatile organic compounds and for large and small particulate matter. Though the Prudhoe Bay field is one of the largest in the world, sample emission quantities from particular units on the North Slope suggest what an oil and gas production facility may emit. For example, the BP Exploration central compressor plant is permitted for 16,719 tons per year of particulates, fine particulates, carbon monoxide, nitrogen dioxide, nitric oxide, sulfur dioxide, VOCs, total hazardous air pollutants, formaldehyde, and hydrochloric acid (ADEC 2011).

Nitrogen oxides comprise roughly 90 percent of the total, followed by carbon monoxide at about four percent and PM 10 at 1 percent (ADEC 2014). A comparison of the effects of Prudhoe Bay oil development on the environment to the predictions of the environmental impact statement 20 years after it was written showed that ambient air concentration of nitrous oxides and sulfur dioxide were considerably below limits set by national standards. Likewise, sulphur dioxide was well below the national standard and consistently was below the more stringent 24-hour standard (Maki 1992).

Methane is a potent greenhouse gas and the main component of natural gas. In 2012, nearly 29 percent of all methane emissions in the United States were produced by the oil and gas industry, the largest source, according to the EPA. Other estimates have suggested higher levels (Rassenfoss 2015). Two major sources of methane emissions were liquid unloading, which account for 14 percent of methane emissions, and pneumatic controller equipment, which produces 29 percent, and is one of the larger sources of methane emissions in the natural gas supply chain. Pneumatic controllers use gas pressure to control the opening and closing of valves and emit gas as they operate. Liquid unloading is a method to clear wells of excess liquids to increase production. Liquid unloading is more common in older wells (Allen et al. 2013).

Sale Area community members cite air pollution the most significant effect of development on peoples' health and the health of subsistence resources. Air pollution is often reported as a haze which is more commonly identified along the coastlines. As more development occurs, it is believed by residents that more pollution and greater effects on the people will occur (NSB 2009). Residents from the closest community to the Sale Area, Nuiqsut, have expressed concern that air quality in the community is poor. Several air monitoring studies were conducted by the ADEC, Alaska Native Tribal Health Consortium, and the Alaska Department of Health and Human Service to measure air pollutant. None of the studies conducted between 2003 to 2013 found elevated levels of air pollution or respiratory illness amongst Nuiqsut residents (BLM 2017).

b. Mitigation Measures and Other Regulatory Protections

Fuel-burning equipment at oil exploration and production facilities and from vehicles could impact air quality. Dust emissions from roads and construction activities may also occur, but are limited to summer months, when the ground is not covered by snow.

Potential effects from future oil and gas activities would be distributed throughout the area where projects occur. Emissions associated with routine program activities would increase, although all applicable standards would continue to be applied. Maximum concentrations of air pollutants occur close to facilities, and disperse farther from the facilities. The Sale Area has good air quality, and existing and future facilities are required to meet ambient air quality standards (BLM 2012).

Federal and state air quality regulations, particularly the Clean Air Act (42 U.S.C. §§ 7401–7671), AS 46.03, AS 46.14, and 18 AAC 50 are expected to avoid, minimize, and mitigate potentially negative effects. Additional information regarding air quality permits and regulations can be found in Chapter Seven.

2. Reasonably Foreseeable Cumulative Effects on Water Resources and Water Quality

Oil and gas activities that may affect the water resources and water quality in the Sale Area include seismic exploration and overland transport, gravel road and pad construction, gravel mining, ice road and ice pad construction, and water withdrawals to support the construction, drilling, and operations phases and construction of ice roads and pads. Effects on hydrology and water resources include changes in drainage patterns, impoundments, increases in turbidity from dust along roads, creation of erosion and sedimentation conditions at stream crossings, filling of wetlands, lowered lake levels, and spills.

Potential cumulative effects on water quality are related to discharges of drilling muds, cuttings and produced waters, increased turbidity from construction of gravel structures, roads and pipelines, and oil spills. Water use from lakes, ponds or groundwater wells may be required for the construction and maintenance of ice roads and pads, and for blending drilling muds in drilling activities, and for potable and domestic water uses.

Turbidity, which is related to suspended particles in the water column, could increase if pipeline construction or repairs, or gravel structure construction were performed improperly. Water quality characteristics that could potentially be affected by oil and gas activities include pH, total suspended solids, organic matter, calcium, magnesium, sodium, iron, nitrates, chlorine, and fluoride. Potential activities that might affect surface water quality parameters include accidental spills of fuel, lubricants or chemicals, increases in erosion or sedimentation causing elevated turbidity and suspended solids concentrations, and oil spills.

Produced water, as noted above, is water that is trapped in underground formations and brought to the surface along with oil and gas. It is the largest volume of aqueous waste and may be 98 percent of the total volume of waste from exploration and development. The volume of produced water from oil and gas wells is not constant over time. As a well ages, the percentage of water increases and the percentage of oil or gas declines. Produced water is typically composed of inorganic salts, heavy metals, solids, production chemicals, hydrocarbons, benzene, polycyclic aromatic hydrocarbons, and occasionally naturally occurring radiation. (UNEPIE 2007).

Containment ponds for produced water, if used, can contain contaminated water and oil and could be a source of waterfowl mortality (NDG&F 2011). But produced water from drilling typically is injected underground; little treatment is required and underground injection is the least costly option. Underground injection is subject to the federal Safe Drinking Water Act's Underground Injection Control program, which is designed to prevent contamination of public water supply aquifers (EPA 2016b).

Cumulative effects to water resources and water quality from oil and gas exploration, development, and production in the Sale Area and across the North Slope could result from thermokarst, from damaged vegetation and streambanks, water withdrawals from lakes, disruption of natural flows by roads, pads, and river crossing structures, water withdrawals from lakes, gravel mining, and spills (NRC 2003; Trammell et al. 2015).

In studies performed as recently as 2011, oil and gas activities have impacted 18,400 acres of land on the North Slope. An additional 18,400 acres of water resources may have been affected indirectly by oil and gas activities. These effects on water resources are likely to continue and additional impacts may occur. Water withdrawals are necessary for all oil field operations. Permit regulations have maintained water quality and quantity in lakes as natural recharge processes have been sufficient to recharge the lakes each year (BLM 2012).

Although roads would likely be built during the winter months as ice and snow roads, long-term oil and gas development in the Sale Area would require permanent gravel roads. Ice roads are typically constructed for exploration projects and if development of field proceeds, gravel roads often replace them to provide access year-round that is easier to maintain. These will likely be in wetlands where drainages are easily altered by road construction and temporary or permanent impoundments are created which divert, impede, or block flow in stream channels, lakes, or shallow-water tracks. Hydrologic effects include changes to drainage patterns associated with road construction, alteration of floodplains from gravel mining, and water extraction from lakes and rivers for construction of ice roads. Impounded water can produce high flows through culverts, which is likely to produce streambank erosion, channel scour and downstream deposition of sediment if culverts are improperly placed or sized.

a. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities such as exploration, development, production, and transportation could result in adverse effects to the water resources of the Sale Area. Many adverse effects could be lessened by mitigation, but would not be eliminated. Most of the effects to water resources and water quality would result from oil and gas development activities, with construction of roads, permanent pads, stream-crossing structures, and water use from lakes during the winter months being the major contributors. Potential effects include change in surface drainage due to construction of roads and pads, loss of wetlands and associated functions largely from construction of roads and pads and gravel mine development, loss or fragmentation of wildlife habitat, and increased risk of spills.

Permits may contain stipulations on water use and quantity drawn in order to meet standards related to protection of recreation activities, navigation, water rights, or any other substantial public interest.

Water use permits may also be subject to conditions, including suspension and termination of exploration activities, to protect fish and wildlife habitat, public health, or the water rights of other persons.

Effluents discharged by the oil and gas industry are regulated through ADEC's Alaska Pollution Discharge Elimination System (APDES) program (ADEC 2016a). Because of permitting requirements for proper disposal, fish and other aquatic organisms are not expected to be impacted by drilling muds, cuttings, produced waters, and other effluents associated with oil and gas exploration, development, and production. Permanent roads and large-scale fill of wetlands will require a Clean Water Act Section 404 permit, and will be discussed in mitigation.

Mitigation measures included in this best interest finding address water quality and include protection of wetland, riparian, and aquatic habitat, water quality monitoring, stream buffers, and water conservation. A complete listing of mitigation measures can be found in Chapter Nine.

E. Reasonably Foreseeable Cumulative Effects on Fish and Wildlife Uses

As described in greater detail in Chapter Five, in the North Slope Borough (NSB), subsistence foods anchor cultural wellbeing and nutritional health, and security of all food resources is a key issue of public concern (NSB 2012). Subsistence uses of the Sale Area depend on the area’s fish, wildlife, and habitats. Post-disposal oil and gas activities could potentially have negative effects on subsistence uses in and adjacent to the Sale Area. In addition to subsistence hunting and fishing, other important uses of fish and wildlife populations in the Sale Area include sport hunting and fishing.

Potential post-disposal oil and gas activities that could have cumulative effects on these uses of the Sale Area include seismic surveys, discharges from well drilling and production, construction of road and support facilities, and ongoing disturbances from production activities such as pipeline activities, vehicle, boat, and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during development and production.

1. Potential Effects on Subsistence

For centuries, survival in the Arctic has centered on the pursuit of subsistence foods and materials as well as the knowledge needed to find, harvest, process, store, and distribute the harvest. The development of Iñupiat culture depended on handing down traditional knowledge and beliefs about subsistence resources. Community well-being depends on the continued use of subsistence resources because of their cultural and economic significance. The subsistence way of life, with its associated values of sharing food and influence on the extended family and traditional knowledge, is considered an integral part of being Iñupiat (Kruse et al. 1983). In addition to this cultural component, subsistence is the direct source of economic well-being for NSB residents.

Subsistence activities could be impacted by oil and gas activities including disturbance from seismic surveys, displacement of resources, limits on access to hunting areas, discharges from well drilling and production, construction of support facilities, and ongoing disturbances from production activities such as vehicle, boat, and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during development and production. Finally, any impacts to specific animal and bird species described in Section F can impact subsistence.

a. Disturbance

Impacts of development on the natural environment have been documented extensively. Development activities may create noise, contamination, and land use restrictions due to the alteration of physical features. All of these may cause loss of vegetated area, loss or transformation of natural habitat, change in migration patterns, and other changes that affect subsistence harvests (NSB 2009).

Anthropogenic activities are likely to influence access and availability to subsistence resources (BLM 2012). Air traffic is perceived as the most severe threat to subsistence harvest. Air and road traffic can disturb caribou causing herds to flee and disperse. Pipelines, if not constructed properly, can influence caribou movements while seismic exploration activities are an impediment to caribou ground traffic. While these activities are not actual physical barriers to accessing any part of the Sale Area, strong perceptions of the threat make them physical barriers for subsistence hunters (MMS 2010). Pipelines, roads, and other infrastructure facilities fragment the habitat and potentially alter migration patterns, thereby creating access issues and affecting the availability of subsistence resources.

Problems may arise after major accidents, and mostly from oil spills. Noise from onshore seismic surveys may cause whales to alter their course of travel. Observations in the Beaufort Sea found localized displacement of bowhead whales and a return to normal numbers in the area 12–24 hours after air guns had ceased firing. Despite the activity, the bowhead population has been steadily increasing since the 1970s and has almost tripled since then (AEWC 2017).

Although noise, traffic disturbance, and oil spills might produce short-term impacts on subsistence species, these impacts would probably not lead to the elimination of any subsistence resource (MMS 2007). Most potential impacts to subsistence species associated with oil and gas exploration, development, transportation, and production would be localized and would probably not substantially affect subsistence species numbers if the activities occurred outside of key habitat areas or migratory zones when animals are present (BLM 2005).

i. Seismic

Seismic surveys are common post-disposal oil and gas activities and can cover a large area. Because seismic exploration by vibroseis occurs during the winter months, the primary subsistence activities that may be impacted include fishing, trapping, and caribou and furbearer hunting. Seismic activity has the potential to affect the terrestrial subsistence resources including furbearers, caribou, seals, whales, muskoxen, and brown and polar bear among other wildlife species. Statements by community members from Utqiaġvik and Nuiqsut have indicated that seismic exploration interferes with overland travel by snowmobiles (BLM 2018). Specifically, ruts left in the snow by seismic vehicles freeze, creating difficult terrain to traverse, resulting in excessive wear-and-tear on both snowmobiles and the sleds that are pulled behind them. Additionally, there is the potential for a machine to become inoperable, which would require search and rescue services. Replacement or repair of these tools that are used for subsistence harvesting could be costly.

The use of air guns for boat-based seismic work could occur in or adjacent to the Sale Area during the summer. Air guns have been shown to affect mortality in eggs and juvenile fish, and result in flight response for adult fish. These activities could affect the subsistence harvest of broad whitefish, arctic grayling, burbot, and lake trout in the Miguakiak and the Ikpikpuk rivers. There is potential for long-term impacts to subsistence fishing if large quantities of eggs or juvenile fish suffer mortality. Altogether, these effects could result in lower harvests for subsistence users.

b. Displacement

Changes in population distribution or migratory patterns due to the presence of oilfield facilities or activities may affect availability for subsistence harvest in traditional subsistence use areas. Overall, impacts to subsistence harvest and use may have problematic impacts with community health, welfare, and social structure. To the extent that subsistence hunting success is reduced in traditional use areas, subsistence hunters may travel farther to new hunting grounds. This could result in greater time spent away from the community for some household members and competition for resources with members of other communities. These changes in subsistence patterns may result in stress within households, family groups, and the community.

In a 2010 survey, residents of Nuiqsut, a community adjacent to the Sale Area near oil development, reported traveling longer distances for subsistence hunting. A few residents reported hunting substantial distances east and west of the community, although some residents commented that hunting has declined east of the community due to activities associated with oil and gas development. Respondents to the survey commonly indicated that they look for caribou while hunting wolf and wolverine by snowmachine over a large area. Residents generally did not travel past the Sagavanirktok River to the east in search of caribou, but one individual reported traveling as far west as Utqiaġvik between 2000 and 2010 (Trammell et al. 2015).

If new discoveries occur and development ensues, the number of development-related facilities might increase. If subsistence hunters were displaced from traditional hunting areas, they might have to travel greater distances and spend more time harvesting resources. However, increased access to hunting, fishing, and trapping areas, due to construction of new roads, could make access to subsistence areas easier and faster, but could also increase competition between user groups for subsistence resources. If competition were to increase, game managers might restrict non-subsistence hunting and fishing.

c. Oil Spills

A major oil spill could decrease resource availability and accessibility, and create or increase concerns about food safety which could result in significant effects on subsistence users, effects which could linger for many years. For example, subsistence harvests of fish and wildlife by residents of 15 predominately Alaska Native communities, as well as by residents in larger rural communities, declined by as much as 70 percent after the 1989 Exxon Valdez oil spill (Fall 1999). Within two years of the spill, subsistence harvests and participation had returned to pre-spill levels, although communities closest to the spill lagged behind. However, concerns remained about food safety, availability of many species was reduced, efficiency was reduced, and opportunities to teach subsistence skills to young people were lost. By 2003, harvest levels were higher than pre-spill levels, or were within the range of other rural communities. However, harvest composition remained different from the pre-spill composition, and concerns about the safety of some shellfish species remained (Fall 2006).

d. Mitigation Measures and Other Regulatory Protections

Although post-disposal oil and gas activities could potentially affect subsistence uses, primarily as secondary effects from effects on habitat, fish, or wildlife, measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects. In addition to mitigation measures addressing fish, wildlife, and habitat, other mitigation measures specifically address harvest interference avoidance, public access, road construction, and oil spill prevention. A plan of operations must include a training program to inform each person working on the project of environmental, social, cultural, health, and safety concerns. Local communities have a unique understanding of their environment. Involving residents in the planning process for oil and gas activities can be beneficial to the industry and to the community. A complete listing of mitigation measures is found in Chapter Nine.

2. Potential Effects on Sport Fishing and Hunting

Sport hunting and fishing activities in and adjacent to the Sale Area depend on the area’s habitats for wildlife and fish. Therefore, potential cumulative effects from oil and gas exploration, development and production on the area’s terrestrial and freshwater habitats could also affect these uses. Potential effects to the area’s habitats are discussed in Section F, and are similar to the effects on subsistence resources.

Oil and gas exploration, development, and production could result in increased access to hunting and fishing areas. Impacts to sport fishing and hunting during drilling and operations are considered to be minimal due to the lack of access and short season. The construction of new gravel roads may increase recreational access to a larger area than is currently accessible via roadway. Cumulatively, there would be more activity, more human presence, increased noise, increased aircraft use, change in location of hunting and fishing activities, and correspondingly greater impacts on the setting, and could also increase competition between user groups for wildlife and fish resources (Trammell et al. 2015).

a. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on uses of wildlife and fish populations, such as hunting and sport fishing. Most of these potential effects would likely occur as secondary effects from effects on habitats, wildlife, or fish. Mitigation measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies, are expected to avoid, minimize, and mitigate those potential effects. In addition to mitigation measures addressing habitats, wildlife, and fish, other DO&G mitigation measures specifically address harvest interference avoidance. A complete list of mitigation measures for this Sale Area can be found in Chapter Nine.

F. Reasonably Foreseeable Cumulative Effects on Terrestrial Habitats and Wildlife

In arctic environments, the largest effects of oil and gas activities are from physical disturbances. Oil and gas development may adversely affect terrestrial habitats through direct loss or fragmentation of habitat from the footprint of associated infrastructure development, including roads, pipelines, pads and facilities, or contamination of habitat. These developments may affect terrestrial wildlife and birds through direct mortality and displacement, reduced reproductive rates, and creating more suitable conditions for predators (NRC 2003).

Activities such as seismic surveys, road and other construction activities, and ongoing vehicle and human movements may contribute to behavioral changes in wildlife due to disturbance and alteration of habitat. Important terrestrial mammals that may experience cumulative effects of oil and gas development in the Sale Area include caribou, brown bear, muskox, and furbearers.

Post-disposal oil and gas activities that could contribute to the cumulative effects to terrestrial mammal habitat in and adjacent to the Sale Area include development, transportation, and road construction. These activities involve construction of infrastructure that could negatively impact habitat within the immediate footprint of the project and indirectly affect habitat through dust, flooding, changes in natural drainage patterns, snow drifting, increased water and air pollution, and oil and chemical spills.

1. Potential Effects of Exploration, Development and Production, and Transportation on Terrestrial Habitats

The process of finding and producing oil in the Sale Area requires various activities that could impact vegetation and habitats. These activities include the development of considerable infrastructure, including well sites, hundreds of miles of pipelines and roads, airstrips, and numerous oil production facilities and living facilities. Habitat fragmentation, especially for large mammals, is an established consequence of such extensive development.

a. Effects of Seismic Surveys

Oil and gas production activities in the Sale Area require off road travel across the tundra in winter for seismic exploration activity, ice road construction for exploratory drilling, and routine maintenance of infrastructure such as pipelines. Modern exploration techniques and equipment coupled with limitations on the timing of tundra travel have mitigated the most severe impacts on vegetation, active layer, and permafrost characteristics (ADNR 2015). However, evidence of past practices such as travel on unfrozen ground or removal of vegetation during seismic testing remains visible on the landscape. Although current practices specify minimum snow depths and ground hardness before tundra travel is allowed, impacts to vegetation and underlying permafrost can still occur. The footprint created by seismic exploration over the last decades covers a larger geographic area than all other direct human impacts combined (NRC 2003).

Winter seismic surveys can affect tundra vegetation based on snow depth, vehicle type, traffic pattern, and vegetation type. Soil-water content and freeze-thaw 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 upon freezing (Richter-Menge et al. 2016).

Effects from seismic surveys during any season could be substantial if operations are conducted improperly. Vehicles may leave visible tracks in the tundra, but these should 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, increasing the likelihood of recovery. Damage has been observed to shrubs, forbs, and tussocks in the Sale Area, with more significant impacts observed on higher, drier sites, with little to no evidence of damage observed in wetlands (NRC 2003).

The evolution of seismic technology in the field is in the intensity of data acquisition, the sensitivity of the instrumentation and precision that the equipment can be located using global positioning satellite system. Advancements in the digital processing of the acquired data and the resultant resolution of the subsurface stratigraphy has led to better seismic interpretation on the North Slope resulting in higher success rates for exploration wells. It is anticipated these advancements will create greater efficiency in exploration with fewer effects on the environment (U.S. Senate 2011).

b. Habitat Fragmentation

Habitat fragmentation occurs when isolated areas of habitat are created due to a disturbance, like a pipeline or road. Pipelines or roads reduce or prevent individuals from moving between patches of habitat and can result in a barrier effect. Habitat loss and more isolated habitat patches are the primary elements of habitat fragmentation. All of these can result in altered ecosystem processes and lower biological diversity (Dunne 2009).

There are two primary means of mitigating the physical barrier created by above ground pipelines, elevating the pipeline clearance to facilitate movement underneath, and constructing the pipeline crossing structures to facilitate movement over the pipeline. Elevated pipelines with a pipeline clearance of at least six feet have proven effective in facilitating wildlife movement, particularly for moose (Dunne 2009). Snow depths can influence wildlife movement under a pipeline as the snow decreases the amount of clearance between the ground and the bottom of the pipeline. Studies showed that pipeline clearances between 2.25 and 4.5 feet impeded moose movement. Researchers observed less change to movement patterns where pipelines were elevated at least six feet and moose could move freely underneath (NRC 2003).

c. Effects of Construction Activities

Effects of constructing production pads, roads, and pipelines include direct loss of habitat acreage due to gravel infilling and loss of dry tundra 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. An analysis of the impacts to habitats related to the construction of TAPS showed the greatest loss of habitat was from gravel material sites used for construction materials, followed by the work pad area and roads causing the second greatest percentage of habitat loss. A secondary effect of construction activities is dust deposition, which may reduce photosynthesis and plant growth (Truett and Johnson 2000).

The effects on the ecosystems impacted by roads include potential chemical input from roads to waterbodies and the airshed and bioaccumulation in soils. Roads can impact sediment transport and floodplain ecology. When roads alter habitats, invasive plant species can be introduced and some plant species may be changed or removed. Additionally, new roads can change the density, composition, and populations of wildlife species. The effects of roads can also include physical disturbance, habitat loss or fragmentation, and threatening or extinction of populations and species near the roads' edge, mortality of wildlife on roads, the use of road edges as habitat, and dispersal of wildlife along road networks (NRC 2005).

The North Slope presents special technical challenges to rehabilitation and restoration. Extremely cold temperatures, minimal precipitation, and the short growing season lengthen recovery times substantially beyond those possible elsewhere in the United States. Recovery of disturbed sites on the North Slope is complicated by the fact that any disturbance of the insulating vegetative mat can melt the underlying permafrost, a process that is extremely difficult to reverse and that can continue long after the initial disturbance ends (NRC 2003).

Tundra sodding, a new technique available to rehabilitate disturbed wetlands in the Arctic, is based on Inupiaq traditional knowledge. The use of tundra sod, comprising blocks of intact soil with a fully-developed plant canopy and root system, arose from Inupiaq's use of sod blocks to construct traditional sod houses and insulate the roofs of ice cellars. Tundra sod also establishes a fully-developed root system, which provides protection against erosion much faster than plants developing from seed (Cater et al. 2015). However, the actual activities and techniques needed to rehabilitate a disturbed site will be a function of its configuration and any future planned uses of the site (Arcadias 2014).

d. Accidental Discharge and Spills

Chemicals used in the exploration, drilling, development, and transportation of oil and gas can be released to the land, water, or air either by accident or as a by-product of routine operations. The addition of pipeline and associated facilities and roadways, increase the amount of stored and transferred oil and other petroleum and gas-related fluids, which in turn increase the potential for spills. Likewise, the development of offshore infrastructure and onshore support infrastructure would also have an additive cumulative impact as the potential for spills increases (AMAP 2013). Spills associated with vehicle use on gravel or ice roads are mitigated by the drips and drops program in place at most North Slope facilities. Spills confined to roads and pads can typically be cleaned up without substantial damage to water or vegetative resources.

e. Releases of Drilling Muds and Produced Water

During exploration well drilling, muds and cuttings are stored on-site, in holding tanks, or in a temporary reserve pit, and then moved to an approved solid waste disposal site, or are reinjected into the subsurface at an approved injection well. Common drilling fluids contain water, clay, and chemical foam polymers. Drilling additives may include petroleum or other organic compounds to modify fluid characteristics during drilling (AMAP 2013). The down-hole injection of drilling muds and cuttings are unimportant if they are not placed into the subsurface into a drinking water aquifer. 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).

f. Oil Spills

The release of hydrocarbons can have toxic effects on vegetation, soils, wildlife, birds, and fish. Effects of spilled oil on the tundra would depend on the time of year, vegetation, and terrain. Oil spilled on the tundra would migrate both horizontally and vertically, with the characteristic of the soil, including porosity, permeability, texture, water-saturation, and organic matter content affecting movement. The oil alone would decrease plant growth, but would leave organic mat intact (NRC 2003). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects such as mortality or reduced regeneration would 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. Tundra recovery from a crude oil spill in Prudhoe Bay showed complete vegetation recovery within 20 years without any cleanup. Natural recovery in wet habitats may occur in 10 years or less if aided by cleanup activities and the addition of fertilizer (Jorgenson and Carter 1996).

Oil spills could damage soils by altering vegetation patterns and by surface disturbance associated with clean-up activities. In some cases, spill cleanup would be more likely to damage soils than allowing some residual oil to remain in place. Oil weathers over time, and organisms may be able to tolerate the presence of oil while it is naturally degrading (Jorgenson and Carter 1996). The long-term effects of oil may persist in 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 (NRC 2003).

Active cleanup measures must be planned to avoid additional adverse impacts such as inducing thermal degradation, use of tundra damaging equipment and manpower activities, and further oil movement during thawing conditions. Oil-spill cleanup would mitigate impacts on soils only if cleanup methods and operations were very carefully controlled and minimized surface disturbance. The area affected would be limited to the area immediately adjacent to and covered by the spill (NRC 2003).

g. Mitigation Measures and Other Regulatory Protections

Terrestrial mammals can move away from sources of disturbance and contamination, or find new habitat. Many studies have examined the responses of different species in the Sale Area to roads, construction, pipelines, ground and aerial traffic, and gravel pads, but it is difficult to assess the long-term effects on the health and population of those species. There is little available data to compare the usability and value of damaged or disrupted habitats with the undisturbed habitats that is still available. There are also many influences that contribute to the behavior and habitat selection of the different species like weather, predation, and changes in population that are not dependent on the construction of oil and gas infrastructure, roads, or pipelines.

DMLW regulates the use of tundra on the North Slope to prevent significant damage to the tundra. Each year, DMLW determines the date when winter tundra travel is open and when it will close. DMLW has determined that damage to vegetation can be avoided by limiting travel to areas with at least six inches of snow cover in wet sedge vegetative environments and nine inches in tussock tundra, by monitoring soil temperature and avoiding minimum radius turns. In areas where damage is extensive and natural recovery is not expected, operators may be required to restore the area. The use of non-native plants is discouraged in certain habitats. The rehabilitation of oil and gas sites, as set forth in the lease agreement, must be accomplished to the satisfaction of DNR. The specific directive can be found under "Rights Upon Termination" in current lease agreements (ADNR 2015).

Post-disposal oil and gas activities could potentially have cumulative effects on terrestrial habitat. Mitigation measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects. For example, impacts to important wetlands must be minimized, exploration facilities, including exploration roads and pads, must be temporary and constructed of ice. The preferred method for disposal of muds and cutting from oil and gas activities is by underground injection, a method that is expected to continue. A listing of administrative authorities can be found in Chapter Nine.

2. Reasonably Foreseeable Cumulative Effects on Caribou

Post-disposal oil and gas activities have the potential to impact caribou from the Porcupine caribou herd (PCH), the Central Arctic caribou herd (CAH), the Teshekpuk caribou herd (TCH), and to a lesser extent the Western Arctic caribou herd (WAH). The impacts on caribou as a result of habitat loss and disturbance to animals are discussed in general terms under the previous section that discusses impacts on terrestrial habitats. Caribou may be affected by temporary ice roads and pads, and by disturbance caused by construction and operations, especially during migration and calving periods. The footprint of facilities is a good indicator of potential impact to caribou; however, the activity occurring at production pads, roads, and airfields produce different impacts to caribou (Trammell et al. 2015).

The principal herd using the Sale Area is the CAH, although caribou from each herd may be found in parts of the Sale Area throughout the year. The caribou herds that use the Sale Area have grown over the last 30 to 40 years, although there have been cyclical declines and substantial mixing and emigration between herds in recent years as ranges expand and shift. Current population estimates, trends, and caribou range data are discussed in Chapter Four.

Research regarding the effects of oil and gas development in the Sale Area on North Slope caribou herds has been contentious. Although much research has been conducted on caribou in the North Slope region, researchers have disagreed over the interpretation and relative importance of some data and the seriousness of data gaps. Since 1975, government and industry have conducted research on caribou biology and on various aspects of their interactions with North Slope oil and gas developments. Population characteristics such as calf production and survival, and adult mortality, habitat use, movement and distribution, and behavioral responses to oil and gas developments have been widely studied. Some research indicates that populations are subject to the natural cycles in the ability of the land to support large numbers of caribou, while others think caribou numbers are influenced by many factors such as disease, nutrition, predator abundance, insect harassment, and weather.

> Demonstrating cause-and-effect relationships between resource extraction and wildlife populations is complicated by natural variation in caribou behavior, population trends, habitat selection, and climate. Detection of potential industrial impacts to the CAH has been

further hampered by insufficient long-term distributional data collected prior to surface development (Person et al. 2007).

Potential impacts can occur at all phases, but are most likely to occur during development and production. Potential effects to caribou populations discussed below include habitat loss and displacement from insect relief and calving areas due to construction, operations, and from oil spills.

a. Potential Effects on Caribou Populations

Resource extraction and infrastructure development have caused the fragmentation of caribou habitat throughout the Sale Area. Research in Prudhoe Bay regarding the interplay between human activity and caribou avoidance or displacement has produced conflicting results.

i. Seismic

Loss of habitat and disturbance (including noise) are the two primary factors associated with seismic activities and exploration drilling that could affect mammals on the North Slope. Until the past two decades, seismic testing resulted in few conflicts with caribou on the North Slope (NRC 2003). Seismic surveys on the summer ranges of the CAH and WAH were conducted during winter, when the animals were rarely present. In a few cases, winter seismic survey areas at times overlapped with the CAH, TCH, and WAH winter ranges, but impacts were probably limited to small groups of animals. In the past 20 years, exploration has increased in and adjacent to the Sale Area, extending into the National Petroleum Reserve – Alaska (NPR-A), as well as into the foothills of the Brooks Range south of the Sale Area. These areas are within the winter ranges of the TCH and CAH (Nicholson et al. 2016; Parrett 2015). It is likely that these activities briefly disturbed and displaced TCH caribou near seismic grids, exploration drill sites, and along ice roads and aircraft transportation routes (Person et al. 2007). However, it has been assumed that these effects did not persist after exploration was completed, and there was no consequential effect on the abundance or productivity of the caribou. This assumption has not been scientifically tested; however, and conditions for winter survival vary from year to year. It is possible that this disturbance could have an additive effect on natural winter mortality and could disproportionately impact young of the year and pregnant cows. Such an impact over several years could accumulate and reduce the productivity of the caribou herds involved (AMAP 2013).

Potential causes of disturbance from seismic activities and overland moves include helicopter and fixed-wing aircraft traffic, surface-vehicle traffic on ice roads, and presence of humans. The response of caribou to disturbance is highly variable, ranging from no reaction to violent escape reactions depending on the distance from human activity, the speed of the approaching disturbance, the sex, age and physiological condition of the animals, the size of the caribou group, and the season, terrain and weather (Harper 2013).

Other sources of habitat loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads have been replaced in recent years by ice roads, airstrips, and drilling pads to reduce the costs and environmental effects of gravel construction. Impacts from ice roads and pads are short-term and are not expected to accumulate. As a result, only a small amount of caribou habitat is likely to be affected long-term by exploration activities such as seismic (BLM 2012).

ii. Disturbance

The movement of caribou herds through their habitat may be affected by pipelines, roads, infrastructure, and the presence of humans. Disturbance of caribou from road traffic associated with pipelines has been shown to cause short-term displacement of caribou within about 1 mile of the road, and up to 2.5 miles for parturient females and calves and subsequent abandonment of some calving habitat (USGS 2002). Earlier studies suggest the road traffic has delayed the successful crossing of pipelines and roads by caribou, and could have adverse energetic effects on some animals. However, recent studies have begun focusing on the intensity of a use area as opposed to only looking at whether or not the caribou successfully crossed a road or pipeline, to determine if caribou behavior is influenced more by the obstruction or by the behavior of other members of the herd (Wilson et al. 2016).

A recent study analyzed the first passage time of 216 caribou in response to a road near Red Dog Mine between 2004 and 2012. First passage time measures the intensity of a use area by determining how long it takes an animal to cross a circle of a given radius (Wilson 2016 citing Fauchald and Tveraa 2003 and Freitas et al 2008). The road is approximately 40 feet wide and has no lateral barriers or linear features that might deter caribou from crossing. Average traffic levels are just over 4 vehicles per hour, 24 hours a day (Wilson 2016 citing Tetratech 2009). The WAH and CAH come in contact with the road. Primary period of contact is during autumn migration, but individuals from the WAH can also encounter the road in summer and winter (Wilson et al. 2016).

Of the 216 caribou monitored for the study, 263 different migration paths were identified and only 32 individuals came within nine miles of the road during the study. Of the 32 individuals that encountered the road, only four never crossed the road, remaining north of the road throughout the migration period. For the 28 that crossed the road, 20 were identified as normal crossers and eight were identified as slow crossers. The average time between first coming within nine miles of the road and finally crossing was approximately 33 days for slow crossers compared with approximately 3.1 days for normal crossers. Earlier studies assumed caribou behavior was a direct response to the road, but researchers now speculate if caribou response to roads is based on the behavior of other caribou (Wilson et al. 2016).

Another study monitored the response of the PCH to human disturbances in their winter range from 1985 to 2012. Researchers calculated the distance of each caribou from existing human settlement, all-season roads, winter roads, trails, seismic lines and well sites. Roads, wells, trails, and seismic lines were more common and occurred in the areas occupied by caribou in the winter. Caribou location data were split into two groups, the early monitoring period from 1985 to 1998, and the late monitoring period from 1999 to 2012. Although caribou avoidance responses varied by type of human disturbance, researchers consistently observed caribou at greater distances away from the nearest human disturbance during the early monitoring period than observed during the late monitoring period. Caribou demonstrated a more definitive avoidance response to main roads with an observed distance of approximately 18 miles during the early monitoring period and more than 11 miles during the late monitoring period as compared to the avoidance response of approximately seven miles and four miles respectively, to wells, trails, winter roads and seismic lines. These data suggest that caribou may become habituated to the footprint or activities associated with human disturbances (Johnson and Russell 2014).

Data collected from 1998 to 2008 showed a zone of influence of approximately eight miles from large open-pit mining operations with a cumulative footprint of more than 15 square miles. The "zone of influence" is the distance at which caribou change their behavior, habitat selection, and distribution relative to disturbance. The same study also noted that the zone of influence coincided with the geographic scale of dustfall suggesting that the level of total suspended particles in the air may contribute to the reduced use of areas within the estimated zone of influence (Boulanger et al. 2012).

iii. Displacement and Habitat Loss

Oil development in the Prudhoe Bay-Kuparuk River Unit area has caused displacement of CAH caribou from a portion of the calving range, with a shift in calving distribution away from the oil fields (NRC 2003). The reduction in calving habitat use near oil development facilities could eventually limit the growth of Arctic caribou herds within their present ranges and prevent the herds from reaching the maximum population size that they could achieve without the presence of development. Caribou cow and calf groups appear to be the most sensitive to disturbances, especially in the summer and immediately after calving, while bulls appear to be least sensitive all year. This is consistent with earlier studies that observed avoidance response in migratory caribou herds on their summer range. It is possible that such an effect would not be apparent, however, because natural changes in the distribution and productivity of the herds may influence the abundance and growth of caribou populations over and above the effect of reduced habitat use caused by cumulative oil development. However, displacement in the Prudhoe Bay-Kuparuk River Unit does not appear to have significantly impacted the population of the CAH. In fact, the CAH steadily increased from 5,000 animals to more than 27,000 animals from the initial population estimate in 1975 to 2000. The CAH continued to grow and the herd was estimated at over 70,000 caribou in 2010 (Lenart 2015c).

Oil and gas development has altered the distribution of female CAH caribou during the calving season and interfered with caribou movements between inland feeding areas and coastal insect-relief areas. Female caribou may also experience lower parturition rates when in close proximity to oil field development. It has also been suggested that declines in CAH caribou productivity in the early 1990s may have been the result of additive impacts of oil field development and high insect activity, although populations of TCH and CAH caribou have increased between the mid-1970s and 2010. Between 1998 and 2010, the CAH increased at a rate of approximately 12 percent annually, and the PCH grew at an average annual rate of 3 percent between 2001 and 2013 and 5 percent between 2010 and 2013 (Parrett 2015; Lenart 2015a). Thus, disturbance of caribou due to oil field development may adversely affect caribou populations, but these impacts are not readily apparent based on population trends. The WAH, whose range does not overlap the current oil fields and whose insect-relief habitat is not on the coastal plain, increased in numbers until about 2003 and has experienced a period of decline from 2003 to 2013 (Dau 2015).

Although direct habitat loss from cumulative oil and gas development in the Sale Area would affect only a small proportion of the total area, indirect habitat loss, or functional loss, could result from long-term displacement of wildlife from the vicinity of oil and gas activities and could involve a much larger area. Future gas and both conventional and unconventional oil exploration and development between the Colville and Canning rivers could increase the amount of activity within the CAH caribou range. Future oil and gas activity in the Sale Area could expose a large number of the TCH and WAH caribou to exploration and development activities on their summer and winter grounds, and during migration (Wilson et al. 2012).

The reduction in calving habitat use near oil development facilities could eventually limit the growth of arctic caribou herds within their present ranges and prevent the herds from reaching the maximum population size that they could achieve without the presence of development. It is possible that such an effect would not be apparent, because natural changes in the distribution and productivity of the herds may influence the abundance and growth of caribou populations over and above the effect of reduced habitat use caused by cumulative oil development. A broad-scale analysis of resource selection functions for the TCH indicates that the landscape characteristics amenable to calving are primarily concentrated in the area north, east, and south of Teshekpuk Lake. The analysis then suggests that if TCH females are displaced from part or all of the current calving area, parturient females would be unlikely to find similar areas elsewhere across their range. This situation could result in reduced calving success and negatively affect the TCH at the population level (Wilson et al. 2012).

Oil and gas development adjacent to the Sale Area could for the first time introduce such infrastructure and activities into the winter range of the TCH. The TCH has experienced seismic exploration and activities near villages for many years, and some herd members on the periphery of the range have been exposed to oil field facilities in some years, but there is no evidence yet of adverse effects other than increased hunting mortality for those animals close to villages. It is not known what population effects might occur if the majority of the herd were to have year-round contact with oil and gas facilities and activities. However, negative effects could result in reduced energy reserves during winter causing increased winter mortality or a reduction in calf productivity (Wilson et al. 2014; Person et al. 2007; Parrett 2015).

iv. Effects of Transportation - Pipelines

Caribou in North Slope oilfields have grown accustomed to above-ground pipelines, as long as traffic on associated roads is infrequent and does not create a barrier. However, they can be sensitive to human activities in calving areas (OPMP 2006). The authors of the Alaska Department Fish and Game (ADF&G) report *Effects of Oil Field Development on Calf Production and Survival in the Central Arctic Herd* write:

> Several studies have suggested that, during the calving season in late May to late June, pregnant caribou cows and those with newborn calves avoided areas of disturbance associated with oil exploration and extraction. During the 1990s, the area of greatest concentration of calving by the western segment of the Central Arctic herd shifted southward as development of oil-related infrastructure occurred in what was originally a major calving area (ADF&G 2009).

During early oilfield activity and pipeline construction people were concerned about the effect of the expanding oil development would have on caribou. Although there was some displacement of caribou calving in the Prudhoe Bay oilfield, in general, caribou have not been adversely affected by human activities in Alaska. Pipelines and most other developments are engineered and constructed to allow for caribou movements, and caribou have shown that they can adapt to the presence of people and activity (ADF&G 2017). Development of onshore oil and gas resources in or adjacent to the Sale

Area could result in construction of one or more additional aboveground pipelines that would pass through the NPR-A. For lands adjacent to the Sale Area, construction of a pipeline may temporarily disrupt movements of the CAH and TCH.

v. Accidental Discharges and Oil Spills

Spills associated with reasonably foreseeable future projects could affect terrestrial mammals on the North Slope. Cumulative effects would depend on the number, size, location, and timing of spills, the type and effectiveness of the oil spill response, and the species and population of terrestrial mammals exposed to the spill. Caribou that become oiled could die from toxic hydrocarbon inhalation and absorption through the skin. Caribou that ingest contaminated vegetation can experience significant weight loss and aspiration pneumonia that can lead to death (NRC 2003).

Potential oil spills from both offshore and onshore oil activities would be likely to have a small effect on terrestrial mammals because comparatively low numbers of animals would be expected to be disturbed or contaminated, or to ingest contaminated food sources and die as a result. Spills would have mostly sublethal effects on terrestrial mammals and would impact only a very minor percentage of the available habitat. The greatest potential for impact to terrestrial mammals would be through disturbance impacts during response, cleanup, and rehabilitation. Disturbance and displacement due to workers or vehicle traffic and hazing related to cleanup activity could be beneficial to caribou as it would minimize exposure to spilled oil and contaminated habitat (NRC 2003).

The oil industry is required to have oil spill response and clean-up capabilities, and small spills on lands or waters in the Sale Area or in existing or future North Slope oil fields are expected to be contained and cleaned up before substantial mammal and habitat loss can occur. In addition to mortality through direct contact with oil, some mortality could result through ingestion of contaminants in food and water from the cumulative effects of the numerous small spills expected from the operation of any oil field. Indirect impacts to mammals through habitat loss would likely be negligible due to the small number of acres affected.

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on caribou. Most of these potential effects would likely occur as secondary effects attributed to habitat disturbance. Overall, industry and agency actions in the Sale Area are expected to have minor impacts to caribou herd productivity. The area between the Colville and Canning rivers represents much of the range of the CAH. In some winters, this area is also important habitat for some TCH caribou. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid or mitigate those potential effects. In addition to mitigation measure addressing fish, wildlife, and habitat, other mitigation measures specifically address caribou. Pipelines are designed and constructed to avoid significant alteration of large ungulate movement and migration patterns. Seasonal restrictions may be imposed on activities located in, or requiring travel through or overflight of important caribou calving or wintering areas. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

3. Reasonably Foreseeable Cumulative Effects on Brown Bear

a. Potential Effects on Brown Bear Habitat and Populations

Construction of industrial facilities can result in the alteration or destruction of brown bear habitat, and as the amount of developed area expands so will the effect on bear habitat. Brown bears on the coastal plain are at the northern limit of their range. Densities are low, with the highest levels near the Prudhoe and Kuparuk complexes. The availability of food is limited and their reproductive potential is low; the region is considered marginal bear habitat (Shideler and Hechtel 2000). The infrastructure that supports industrial development in the Arctic substantially increases bear-human interactions.

i. Disturbance

Oil and gas activity in the Sale Area has increased the potential for bear-human interactions due to the increases in human residence and anthropogenic food availability. The availability of anthropogenic food sources affects bear behavior and reproduction. Studies show that food conditioned bears reproduce at a younger age and faster interval than natural-food bears (Bentzen et al. 2014; Lenart 2015b). Studies of brown bear populations that use Prudhoe Bay oilfields showed that bears that consumed anthropogenic foods had higher than average cub survival. However, this increased cub survival was offset by greater-than-average mortality among post-weaned subadults because their conditioning to human foods made them more vulnerable to hunters along the Dalton highway and to defense of life and property killings (Shideler and Hechtel 2000; Bentzen et al. 2014).

Management agencies have employed non-lethal techniques such as hazing, relocation, or translocation with variable success relative to the degree the bear has become food conditioned. Bears with a history of anthropogenic food use are less likely to respond favorably to non-lethal intervention and can lead to an increase in defense of life and property related kills. Bear-resistant food-waste bins, fenced in landfills, and training and management plans implemented by industry regarding proper waste storage has greatly reduced, but has not eliminated, availability of anthropogenic foods in the Sale Area (Bentzen et al. 2014).

ii. Seismic Surveys

Exploration activities, particularly seismic testing and human presence, pose potentially serious disturbances to denning bears. Human activity may initially cause bears to avoid an area and can displace bears in the area. Seismic activity that occurs in the winter may disturb denning bears. Studies have found that radio-collared bears in their dens were affected by seismic activities within 1.2 miles of their dens as demonstrated by an increased heart rate and greater movement within the den. However, no negative effect such as den abandonment was documented (NRC 2003).

iii. Habitat Loss and Displacement

Direct habitat loss could result from construction of well pads, pipelines, roads, airfields, processing facilities, housing, and other infrastructure. Quantifying the number of animals involved is difficult. Brown bears travel along the major river corridors and feed in riparian areas in and near the Sale Area. Siting facilities outside these areas will reduce potential impacts on brown bears (DOG 2008).

iv. Oil Spills

The potential effects of oil spills on brown bears include contaminating of individual animals, coastal habitats, and some local food sources. Bears feed on fish concentrations at overwintering and spawning areas and on carrion along the coast. If an oil spill contaminates beaches, bears are likely to ingest contaminated food sources. If a large oil spill oiled habitats used by bears, cleanup workers and traffic from vehicles and aircraft are expected to disturb and displace these species during cleanup operations, thus minimizing the animals' exposure to spilled oil. In addition, oil spill responders would employ hazing to divert animals from the cleanup area (USFWS 2008). Reports to assess the effect of oil spills on brown bears in the Sale Area were not located.

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on brown bears. Direct habitat loss will result from construction of well pads, pipelines, roads, airfields, processing facilities, camp facilities, and other infrastructure. Primary sources of disturbance include seismic activity, vehicle traffic, and aircraft. Seismic activity that occurs in winter may disturb denning bears. Human activity may attract foraging bears, especially to refuse disposal areas. The potential effects of oil spills on brown bears include contamination of individual animals, contamination of habitats, and contamination of some local food sources.

Before commencement of any activities, consultation with ADF&G is required to identify the locations of known brown bear den sites that are occupied in the season of proposed activities. For projects in proximity to areas frequented by bears, lessees are required to prepare and implement a human-bear interaction plan designed to minimize conflicts between bears and humans. Exploration and production activities must not be conducted within one-half mile of occupied brown bear dens unless alternative mitigation measures are approved by ADF&G. A lessee who encounters an occupied brown bear den not previously identified by ADF&G must report it to the ADF&G's Division of Wildlife Conservation within 24 hours. Mobile activities will avoid such discovered occupied dens by one-half mile unless alternative mitigation measures are approved by the director, with concurrence from ADF&G.

4. Reasonably Foreseeable Cumulative Effects on Muskoxen

a. Potential Effects on Muskoxen Habitat and Populations

Potentially harmful oil and gas exploration, development, production, and transportation activities may include seismic surveys, drilling operations, construction of ice and gravel roads and pads, production facilities, and pipelines. These activities have the potential to impact muskoxen, primarily through noise, physical disturbance, or displacement. A large spill or blowout may further affect muskoxen and their habitat.

i. Disturbance

Reactions by muskoxen to oil and gas activity can differ between groups or from herd to herd. Mixed groups of muskoxen demonstrated a greater sensitivity to fixed-wing aircraft in winter and during calving than in summer, fall, or during rut. Helicopters and low-flying aircraft sometimes cause muskoxen to stampede and abandon their calves (Lenart 2015d).

ii. Seismic

Muskoxen have a year-round presence on the North Slope which makes them susceptible to effects from seismic exploration. However, earlier studies found there have been no effects detected due to 3D exploration. Herd responses vary to noise disruption from seismic programs based on previous exposure. As 3D seismic exploration has expanded, future effects may be identified (NRC 2003).

iii. Habitat Loss and Displacement

Direct habitat loss will result from construction of well pads, pipelines, roads, airfields, processing facilities, and other infrastructure; however, industry will likely rely on existing infrastructure to the extent practical (Ott et al. 2014). Muskoxen have high fidelity to particular habitat areas because of factors favorable to herd productivity and survival such as availability of food, snow conditions, or absence of predators.

Muskoxen survive the winter by using stored body fat and reducing movement to compensate for forage intake and may be more susceptible to disturbances during winter. The energetic costs associated with forced movements during winter may be as significant an impact as disturbance during calving. Displacement from preferred habitat could have a negative effect on muskoxen populations. The magnitude of the effect is difficult to predict, but would likely be related to the magnitude and duration of the displacement (AMAP 2013).

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on muskoxen. Most of these potential effects would likely occur as indirect effects attributed to habitat disturbance. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid, minimize, or mitigate those potential effects. Seasonal restrictions may be imposed on activities located in, or requiring travel through or overflight of, important muskox calving or wintering areas. Pipelines are designed and constructed to avoid significant alteration of large ungulate movement and migration patterns. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

5. Reasonably Foreseeable Cumulative Effects on Furbearers and Populations

a. Potential Effects on Furbearer Habitat and Populations

The term furbearer is used here to describe those species of terrestrial mammals that are routinely sought by trappers who place commercial value on the pelts. Furbearers commonly found in the Sale Area include Arctic foxes, red foxes, and wolves. Historically, Arctic fox were the predominate furbearer in the Sale Area. However, red fox populations are rapidly increasing as their range expands northward. Potentially harmful effects of oil and gas exploration, development, production, and transportation activities may include seismic surveys, drilling, construction of ice and gravel roads and pads, production facilities, and pipelines.

i. Disturbance

Furbearers may be disturbed by oil and gas activity, particularly vehicle and aircraft traffic. Wolves and foxes readily habituate to human activity, leading to human-animal encounters. Primary sources of disturbance are aircraft traffic. Helicopters generally invoke a stronger response from wolves and foxes than fixed-wing aircraft. Ice roads connecting well sites and supply areas would provide a source of disturbance from vehicles. During construction of the Dalton Highway and TAPS, wolves readily accepted handouts from construction workers (USFWS 1987).

Wolves and foxes may be disturbed by wintertime onshore seismic activity. These species are highly mobile and foxes and wolves readily adapt to human presence. Impacts are expected to be transitory (Caikoski 2012; Lai et al. 2015).

ii. Habitat Loss and Displacement

Habitat loss would primarily affect foxes through destruction of den sites. Placement of oil and gas infrastructure at or near den sites may destroy dens or displace foxes causing them to relocate and build new dens. However, since development began in the Prudhoe Bay area in the 1970s, Arctic foxes have been documented using culverts and other construction materials for denning in or around oilfield infrastructure (Gallant et al. 2012).

Foxes are especially attracted to human activity because of potential scavenging sources. Arctic fox density is greater in the Prudhoe Bay complex than in undeveloped areas nearby. In fact, studies suggested that Arctic foxes benefit from camps, communities and oil infrastructure (AMAP 2013; Stickney et al. 2014). Arctic foxes have been documented scavenging for food at dumps and landfills and den around oil related facilities. Arctic foxes readily habituate to human activity and successful litters of pups have been raised within 80 feet of heavily traveled roads and within 160 feet of operating drill rigs (NRC 2003; Gallant et al. 2012).

Between 2005 and 2012, researchers documented a rapid shift in den occupancy and productivity as red foxes displaced Arctic foxes from den sites and breeding territories, becoming the primary and dominant species in the greater Prudhoe Bay area. The benefits realized by Arctic foxes related to oil and gas development have indirectly attributed to the rapid expansion of the range of the red fox. Currently, Arctic fox are more likely to be displaced by red fox than oil and gas activity (Stickney et al. 2014).

The effects of direct habitat loss on wolves would likely be negligible. The abundance of wolves is ultimately determined by the availability of prey. The ability of adult wolves to provide food is the key determinant in wolf pup survival. Low occurrence of moose on the North Slope and only seasonal availability of caribou due to migratory patterns result in lower wolf population in the Sale Area. In relation to other parts of Interior Alaska, wolf population is low due to general absence of prey, but populations have remained stable even though data is limited (Caikoski 2012, 2013).

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on furbearers. Most of these potential effects would likely occur as secondary effects attributed to habitat disturbance. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid or mitigate those effects. Exploration facilities, including exploration roads and pads, must be temporary and must be constructed of ice unless the director determines no other alternative exists. Proper disposal of garbage and putrescible waste is essential to minimize attracting wildlife. Lessees must use the most appropriate and efficient method to achieve this goal. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

6. Reasonably Foreseeable Cumulative Effects on Polar Bear Habitat and Populations

a. Potential Effects on Polar Bear Habitat and Populations

Polar bears may be present in the upland and offshore areas year-round. Impacts to polar bears from oil and gas development could result through habitat loss, disturbance, incidental harassment, intentional hazing, or mortality.

Polar bears are a threatened species under the Endangered Species Act (ESA) that inhabit the coastal areas of the Sale Area. Sea ice, barrier islands, and denning areas along the Alaska coast have been designated critical habitat for the polar bear. The critical terrestrial denning habitat area extends from the mainland coast of Alaska 20 miles landward (primarily south) from the United States-Canada border to the Kavik River to the west. From the Kavik River to Barrow, the critical terrestrial denning habitat extends landward five miles south from the mainland coast of Alaska (75 Fed Reg 76134). See Chapter Four for more information on polar bear listing under the ESA. Polar bears may be present along coastal areas of the Sale Area at any time of the year with pregnant females overwintering in shallow maternal snow dens. Oil and gas activities with the most potential to affect polar bears in the Sale Area include oil and gas exploration and development, aircraft and watercraft traffic, and winter overland travel. These activities could affect polar bears by causing direct mortality from defense of human life, accidental oil spills, and lethal impacts during research activities, altering polar bear behavior, physiology or movements, or disturbing or destroying snow dens, which could cause impacts to cubs at critical life stages, resulting in mortality (BLM 2012).

Changes in sea ice conditions can have cascading effects that increase the magnitude of impacts from other sources of impact. For example, thinning ice and a greater extent of marginal ice stability in the fall may already be leading to reduced sea ice denning, and a corresponding increase in denning on land, in Southern Beaufort Sea bears (USGS 2016). This in turn increases the probability of disturbance to denning bears from human activities. Maternal polar bear dens are documented along the mouth of the Colville River delta. The chances of bear-human encounters in coastal villages and industrial areas also increases with a greater proportion of polar bears coming on land during the fall open-water period, or as the amount of time individual bears spend on land increases (Muto et al. 2016; BLM 2012).

Bears denning near the Prudhoe Bay oil field did not show evidence of being disturbed by humans. In fact, bears near roads showed fewer episodes of vigilant behavior than bears at undisturbed den sites. The researchers concluded that the near-road bears were habituated to traffic. Noise generated by exploration and development, particularly seismic activities, could lead pregnant bears to leave denning habitat or pre-maturely abandon dens. Again, the Prudhoe Bay study showed bears became habituated and did not abandon dens (Amstrup et al. 2006). Research testing noise levels within artificially constructed dens revealed that most vehicle noise was undetectable when the source was over 1500 feet away.

i. Seismic

Because polar bears are listed as threatened species, any activity may require consultation with the US Fish and Wildlife Service (USFWS). In addition, for offshore (including state waters), the USFWS has issued a Beaufort Sea Incidental Take Regulation for the nonlethal, incidental, unintentional take of polar bears and Pacific walrus associated with ongoing oil and gas activities in the Beaufort Sea and neighboring coast (81 Fed Reg 52275). Under this regulation, industry may request a Letter of Authorization for specific activity. Industry must coordinate and consult with the USFWS to avoid disturbance to polar bear dens by one mile, and may require a search for potential polar bear dens prior to any seismic activity or exploration with potential to disturb denning polar bears. Because seismic and exploration activities are required to occur at a physical distance that protects denning polar bears from disturbance, these activities are not thought to present a significant risk to polar bears.

ii. Displacement and Habitat Loss

The primary impacts to polar bears from production-related activities include habitat losses due to construction of production facilities and human-bear encounters. Just over half of polar bear dens are found in offshore pack ice, well north of the Sale Area, and just under half occur on land (Amstrup et al. 2006; Durner et al. 2006). Denning is an integral part of the reproductive process and critical to reproductive success. Maternal denning is widely scattered, which may facilitate human avoidance of denning sites. If disturbances lead bears to prematurely abandon dens before cubs are sufficiently mature, cub survival could be reduced (Amstrup and Gardner 1994).

Alaskan polar bears spend most of their lives on the sea ice; however, bears may be increasing their use of land during the fall open water season. Increased time onshore may be more related to access to seals than human-related food sources, but one consequence of more time onshore is increased human-bear interactions (MMS 2006). Buildings and other structures can attract bears and can become places for bears to scavenge from human waste. This increases the chances that bears will need to be driven away or killed to protect human safety (NRC 2003). Preparation of human-bear interaction plans and proper disposal of garbage will minimize conflicts with bears and humans.

iii. Oil Spills

Oil spills could include direct fouling of polar bears, their prey, or their habitat. These spills could foul ice and shorelines, so the continued risk of direct exposure remains, as does the risk of long-term contamination of both marine and terrestrial habitats. Oiled fur loses it insulating qualities (USFWS 2008).

(Amstrup et al. 2006) conducted a modeling study to predict the probability that polar bears on the North Slope would be exposed to hypothetical oil spills from two locations in the Beaufort Sea, one that is currently operating offshore (Northstar unit) and one that was proposed for about five miles offshore (Liberty unit). While these units are not in the Sale Area, a spill could impact the Sale Area. The model incorporated actual weather data such as wind, ice, and currents, and used National Oceanic Atmospheric Administration (NOAA) methods for modeling oil spills. Data from studies of radio-collared polar bears from 1985 to 2003 were also used. The model examined the worst-case scenario: the largest anticipated catastrophic spill; the largest anticipated chronic spill; the worst possible times, the maximum open water period (September), and the period of maximum polar bear density (October); no attempt at cleanup or other human intervention; and maximum effect (all bears touched by oil killed). The model did not take into account uncertainty in polar bear population estimates or oil weathering. Median numbers of polar bears oiled by a worst-case scenario spill at Liberty were one bear in September and three bears in October; median numbers oiled at Northstar unit were three bears in September and 11 bears in October. Based on this model, there is a very low probability that a large number of polar bears would be affected by an oil spill; and, if an oil spill were to happen, there is a large probability that a low number of bears would be affected (Amstrup et al. 2006).

b. Mitigation Measures or Other Regulatory Protections

Post-disposal oil and gas activities subsequent could potentially have foreseeable effects on polar bears. Most of these potential effects would likely occur as indirect effects on habitat. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies, are expected to avoid, minimize, and mitigate those potential effects. Lessee will comply with all provisions of the ESA and the Marine Mammal Protection Act (MMPA). The USFWS works to monitor and mitigate potential impacts of oil and gas activities on polar bears through ESA and MMPA regulations. Activities operating under these regulations must adopt measures to ensure the total taking of polar bears remains negligible and minimizes impacts to their habitat. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

7. Reasonably Foreseeable Cumulative Effects on Bowhead Whale Habitats and Populations

a. Potential Effects on Bowhead Whale Habitats and Populations

Some mild effects on bowhead whales may come from oil and gas exploration, development, production, and transportation activities. While bowhead whales are not present in the Sale Area, it is possible that onshore activities may have indirect effects through disturbance attributed noise and

i. Disturbance

In the Arctic, industrial sounds and other disturbances have displaced whales from preferred habitats, but these impacts can be difficult to quantify and to determine if they accumulate. Noise and disturbance associated with offshore seismic and drilling activities, and boat and barge traffic have affected bowhead whales, causing deflection and behavioral changes (Richardson et al. 1995). An increase in vessel traffic could result in an increased number of vessel collisions with bowhead whales (Muto et al. 2016). A large body of literature exists about the sensitivity of bowhead whales to industrial sounds and activities; however, it is not known how impacts from these stressors accumulate (NRC 2003). Bowhead populations have been increasing for at least three decades despite oil and gas activities. It is possible, though, that the population could have increased more rapidly in the absence of industrial activities

Studies have shown that bowhead whales respond to anthropogenic sounds by moving away, or altering their surfacing and diving patterns. However, little information is available showing that bowheads abandon an area, travel far, or remain disturbed for extended periods after a ship passes. In terms of displacement from areas with heavy traffic, past observations and studies demonstrate that various cetacean species react differently to long-term disturbances, and consequently, bowhead whale responses to repeated disturbances cannot be predicted accurately (LGL Limited 1991).

ii. Seismic

The results of studies on the effects of seismic survey noise on bowhead whales have varied, and often the variables used between studies were not consistent (Blackwell and Greene 2006). Multiple factors may be important in a whale's response including the physical characteristics of the location into which the sound is released and the physical characteristics of the location where the whale is located at the time the sound is released, group composition, whale behavior such as migrating or feeding, the frequency or duration of the sound, and previous exposure to seismic noise. Seismic in the Sale Area would be vehicle-based survey with negligible effects on whales near the coastline due the distance from shock wave and noise. In a 2007 seismic program, aerial and boat-based surveys of feeding bowhead whales in the Beaufort Sea showed that the whales remained in the vicinity of the seismic work. Researchers found small-scale avoidance immediately near seismic work but a tolerance of higher sound levels closer to the ships (Koski et al. 2008).

Air gun blasts may affect whale behavior, but different studies of different whale species at different times and places have yielded a variety of observations. A study of bowhead whales in the Beaufort Sea found that the use of air guns resulted in shorter surfacing times, fewer exhalations per surfacing, longer blow intervals, and subtle to overt changes in surface behaviors. The whales appeared to tolerate continuous and full-scale seismic sounds at distances greater than six miles. Responses varied within that range depending on the distance from the source. At about five miles, whales began to show avoidance behavior with air guns firing at 158 decibels (dB). At about two miles all whales in the pod showed signs of avoidance (Ljungblad et al. 1988).

iii. Displacement and Habitat Loss

Activities that produce underwater noise could cause bowhead whales to temporarily divert from their route of travel or change behavior patterns in other ways. It is not known if a threshold exists beyond which the number of behavioral changes and displacements may begin to influence individual fitness, long-term changes in movement patterns, shifts in foraging behavior, or access to productive forage areas. If the cumulative increase in disturbance events results in impacts to the fitness of enough individuals, reduced reproduction could result with consequences to the population (BLM 2012).

However, evidence is not conclusive to support the suggestion that permanent changes to feeding or migratory patterns have occurred (Fraker et al. 1985). Biologists believe that little information is available showing that bowheads abandon an area, travel far, or remain disturbed for extended periods after a ship passes. For bowheads, some information is available on how individual animals respond to oil and gas activities but the observations are short-term and provide little usable data for longer-term impacts on individuals or the population. The most intense, and potentially most disturbing, human activities are subsistence whaling, commercial vessel traffic, and marine seismic activities (LGL Limited 1991).

iv. Oil Spills

Oil and gas activity could increase the risk of various forms of pollution in bowhead whale habitat, including spills and other pollutants (Muto et al. 2016). Primary concerns about the potential effects of oil spills on bowheads in the Beaufort Sea include accumulation of oil in eroded areas of the bowhead's skin and around the eye, leading to noxious effects from surface contact with hydrocarbons; accidental ingestion or inhalation of oil while feeding, possibly resulting in lethal or sublethal effects, including gastrointestinal tract obstructions; fouled baleen, resulting in reduced filtering efficiencies; and destruction or contamination of critical food sources from acute or chronic oil pollution. Bowheads could also be affected by passing through residual oil, even if they were not present during the spill (Allen and Angliss 2014). A spill in broken ice, if one occurred, would be more difficult to clean up than one on land or on solid ice. If spilled oil migrated into leads or ice-free areas used by migrating whales, a significant proportion of the population could be affected (AMAP 2013).

Bowhead whales have not been observed in the presence of an oil spill, so it is uncertain if they can detect oil or would avoid surface oil. Bowhead skin, like that of most cetaceans, is mostly soft and smooth. However, it also contains up to several hundred roughened lesions on the surface of the skin. If a bowhead came in contact with spilled oil, it is unlikely that the oil would stick to the smooth areas of its skin, but might adhere to rough areas on the skin surface. If bowheads left the oiled area it is likely that most of the oil would wash off within a short time. However, oil adherence to the roughened parts of the skin has the potential to introduce tissue-destructive pathogens (NRC 2003). Cleanup activities, with associated presence of boats, aircraft, and workers, as well as strategies such as in-situ burning, may also impact or displace bowhead whales (Allen and Angliss 2014).

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have mild effects on bowhead whales traveling near the Sale Area, primarily through noise and disturbance during spring and fall migrations. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid, minimize or mitigate those potential effects. Lessee shall comply with all provisions of the ESA and MMPA. In addition, operators generally work with the Alaska Eskimo Whaling Commission to work under a Conflict Avoidance Agreement to decrease impacts to bowheads and subsistence hunters. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

8. Reasonably Foreseeable Cumulative Effects on Seal Habitats and Populations

a. Potential Effects on Seal Habitat and Populations

As discussed in Chapter 4, there are four ice-associated seal species: bearded, ringed, ribbon and spotted. Long-term productivity of seals is unlikely to be significantly impacted by short-term production and development uses. A large-scale spill is the only action that is likely to have long-term effects on marine mammals after short-term development and production activities have ceased. Seals are marine animals that are rarely encountered the Sale Area.

i. Disturbance

The primary sources of noise and disturbance of pinnipeds would come from marine traffic, drill rigs, air traffic, and geophysical surveys. A secondary source would be low frequency noises from drilling operations. Boat traffic could disturb some pinniped concentrations; however, such traffic is not likely to have more than a short-term (a few hours to a few days) effect. Helicopter traffic is assumed to be a source of disturbance to pinnipeds hauled out on beaches or sea ice. Such brief occasional disturbances are not likely to have any serious consequences. However, spotted seals are one of the most cautious phocid species and are easily disturbed from their haulout sites on land or sea ice (Boveng et al. 2009). Spotted seals will often haul out again in the same place from which they were disturbed when they feel safe again, even though constant or repetitive disturbances may cause pups or haulout sites to be abandoned (Boveng et al. 2009).

Surveys and studies in the Arctic have observed mixed reactions of various seal species to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and enter the water, while seals that encounter vessels in the open water may have little to no reaction. Observations of ringed and bearded seals during open water surveys in 2010 showed only slight aversion to vessel activity. Observations of ringed and bearded seal response to seismic surveys where received noise levels were less than 120 dB showed 56.7 percent of seals responded mainly by looking at the vessel, while 32.8 percent showed no reaction at all. Ringed and bearded seals had a similar reaction to vessels performing non-seismic activities with 37.5 percent observed looking at the vessel and 62.5 percent showed no obvious reaction (LGL 2010). This was consistent with seal behaviors observed during vessel-based monitoring of exploratory drilling operations in the Chukchi Sea during the 2012 open water season. The majority of seals, 42 percent, responded to moving vessels by looking at the vessel, while 38 percent showed no observable reaction (LGL 2013).

Several reports document the responses of seals to low-flying aircraft. The effect is more pronounced if areas where air traffic is uncommon and with helicopters as opposed to fixed-wing aircraft. A greater number of ringed seals responded to helicopter presence than to fixed-wing aircraft presence and at greater distances of up to almost 1.5 miles from the aircraft, suggesting that sound may trigger escape response. Some reports indicate seals may habituate to frequent over flights to the point where there is no reaction (Richardson et al. 1995).

ii. Seismic

Noise and disturbance from seismic operations could cause a brief disturbance response from seals. 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 varying exposure to air gun firing. Seals did avoid a 500-foot zone away from the boat during full-array seismic, but seals apparently did not move much beyond 250 meters. "Swimming away" was more common during full-array than no air gun periods. Affected animals are likely to return to normal behavior patterns within a short period of time (MMS 1996).

Reported seal responses to seismic surveys have been variable and often contradictory, although they suggest that ice seals often remain within a few hundred feet of operating air gun arrays (Kelly et al. 2010; Harris et al. 2001). One study reported that on average, seals in the Beaufort Sea were spotted nearly 500 feet from vessels when seismic surveys were inactive as opposed to over 680 feet when seismic surveys were being conducted. Another study conducted the same year reported seismic surveys in the Beaufort Sea had no obvious effect on the timing or route of ringed seals migrating in the fall (Blackwell et al. 2004).

iii. Displacement and Habitat Loss

Some pinnipeds could be temporarily displaced by construction activities associated with causeway or island construction or creating a gravel drilling or production pad on land. 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.

A study on the abundance and distribution of seals near the Northstar unit indicated that seal densities during spring were unaffected (Moulton et al. 2003). Habitat, temporal, and weather factors affected densities. The researchers concluded that the effect of the Northstar unit presence on basking ringed seals is slight. In another seal study, Moulton et al. (2002) found that industrial activities on landfast ice (ice road construction, drilling from an artificial island, and on-ice seismic surveys using seismic vibrators) did not affect seal densities. Williams et al. (2006) found no evidence that ringed seal use of the landfast ice approximately one mile from Northstar or the ice roads was different than their use of ice one to two miles away. Vehicle traffic on the ice road did not influence ringed seals' use of ice (Blackwell et al. 2004).

iv. Spills

Small contaminant spills are unlikely to have significant detrimental impacts on ribbon or spotted seals, with the exception that numerous small spills over time could have an impact if a small number of animals were to come into contact with each spill. A larger contaminant spill that enters a major waterbody, however, could have detrimental effects on spotted seals and possibly ribbon seals. Spotted seals are known to range large distances up coastal riverways and spend most of the summer in nearshore coastal waters (MMS 2010; Boveng et al. 2009). Spotted seals therefore could potentially come into contact with any large contaminant spill (i.e., crude oil or other production-related products) that enters a waterbody connected to the marine environment, although more seals may be at risk if marine waters are directly contaminated.

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on seals. Both ringed and bearded seals are commonly distributed throughout the coastal portion of the Sale Area, and populations vary considerably with seasonal weather changes. Spring and summertime oil and gas exploration and development activities in the Sale Area and elsewhere in the Beaufort Sea could disturb seals, and could ultimately contribute to some limited displacement. Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid, minimize or mitigate those potential effects. Lessees will comply with all provisions of the ESA as applicable and the MMPA. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

9. Reasonably Foreseeable Cumulative Effects on Fish Habitats and Populations

a. Potential Effects on Fish Habitat and Populations

Most oil and gas development projects would result in some cumulative effects to fish and fish habitat to the extent that they increase the footprint of gravel pads and roads. Oil and gas activities which introduce infrastructure across fish-bearing streams or are perpendicular to hydrologic flow would have a greater cumulative effect on fish and fish habitat. Most potentially negative effects would be limited to the localized area of development.

Major anadromous rivers and streams in the Sale Area include the Colville, Sagavanirktok, Itkillik, Kuparuk, Shaviovik, and Canning rivers. While these are the primary freshwater habitats in the Sale Area, there are many other rivers and streams that support anadromous and overwintering fish populations. Several species of anadromous fish spawn and overwinter in these rivers and migrate to nearshore coastal waters in the summer to feed. Migration patterns vary by species and within species by life stage and are discussed in Chapter Four.

The potential effects on fish because of oil and gas development include injury at water-use intakes, altered water quality, physical habitat changes, point and non-point source pollution, increased turbidity and sedimentation, and barriers to fish movements. Collectively, these could contribute to reduced success at different life stages, behavioral changes, diminished condition, susceptibility to pollutants or disease, shifts in fish species distribution, and mortality.

Some aspects of North Slope oil and gas development and production have caused impacts on fish that have accumulated, while impacts on fish from other aspects have not persisted. Impacts from gravel pads and roads as well as causeways have accumulated by impeding fish movements and significantly altering fish habitat by changing physical and chemical conditions. Year-round freshwater use for domestic facilities, seawater use for waterflooding, and oil spills have all affected fish in ephemeral ways that have not likely accumulated (BLM 2012).

The elements of onshore North Slope oil and gas development and production most likely to contribute to future effects on fish that could accumulate include permanent infrastructure such as roads, pads, pipelines and causeways, and gravel mining necessary to build the infrastructure. The gravel infrastructure and associated gravel mining associated with oil and gas development and production have caused effects to fish that have accumulated by impeding fish movements and significantly altering the physical and chemical conditions of fish habitat (Ott et al. 2014).

i. Development and Habitat Alteration

Potential effects in degradation of stream banks and erosion, reduction of or damage to overwintering areas, habitat loss due to gravel removal, high impact facility sighting, effects due to water removal, siltation, impediments to fish passage and migration, and mortality due to oil spills or other freshwater habitat contamination. Excavation of gravel construction materials can disturb floodplains and habitats. Construction activities can also cause erosion of river banks, siltation, bottom substrate disturbance, reduced water volumes, altered water quality, barriers to fish passage, and elimination of habitat (Ott et al. 2014; IPIECA 2012).

Road development and water withdrawal for oil and gas exploration can affect fish and aquatic habitats in the Sale Area. Erosion is a potential impact of all phases of exploration and development. Major construction, especially of roads, can increase erosion and runoff leading to increased stream turbidity and sedimentation. Increased turbidity and sedimentation could have negative impacts on egg and juvenile survival, as well as potentially reducing or alter stream flow, affecting overwintering habitat availability and the ability of fish to migrate upstream (Brown 2008). Road development at stream crossings could disrupt migratory pathways and alter access between key summering and wintering habitats. Due to the use of small drainages, including ephemeral streams, any development that would impede fish passage within these small drainages, could have negative impacts on broad whitefish populations within the Sale Area (Morris and Winters 2008). Broad whitefish are considered potentially sensitive to water withdrawal activities, especially during the winter when habitat is most limiting. Bridges and culverts used for oil and gas activities could affect broad whitefish habitat directly by increasing sedimentation or altering migration routes. Protecting the integrity of stream bank vegetation and minimizing erosion are important elements in preserving fish habitat (Trammell et al. 2015; Morris 2006).

ii. Seismic

Many species of fish are more sensitive to seismic noise and pressures than are marine mammals. Salmon and herring are sensitive to sound wave frequencies between 100 and 500 hertz (Hz) and peak sensitivities are 80–200 Hz. Their peak sound pressure volume sensitivity threshold is 80–120 dB. Studies have shown various effects caused by seismic pulses, such as fish moving out of the area and becoming more difficult to catch (Wardle et al. 2001).

The effects of seismic noise have been studied on wild and caged freshwater fish as well, with differing results. One experiment showed that northern pike and chub showed no difference between the ear tissues of fish exposed to an air gun blast and those from ear tissues of a control group not exposed to an air gun blast (Song 2008). Conversely, another study showed that air gun blasts caused substantial damage to red snapper ears, which are similar to a salmon's ear structure (McCauley 1998).

Differences between the two studies may have affected the results. The two studies differed in the sizes and numbers of air guns used, the pressures, sound exposures, and recovery times of the fish (24 hours in the Song study versus 58 days in the McCauley study). In the McCauley study, the subjects were caged in shallow water, and bathymetry is one variable that can affect how sound behaves in the ocean. Seismic pulses in shallow water will be higher-frequency than those in deep water (Song 2008). Blasting criteria have been developed by ADF&G and are available upon request. The location of known fish bearing waters and information on blasting criteria can be obtained from ADF&G's Division of Habitat.

iii. Accidental Discharges and Spills

Accidental discharges and spills from oil and gas activities may contaminate aquatic habitats within the Sale Area. Some contaminants that have a long half-life and travel in the upper atmosphere have both local and distant anthropogenic sources, alternatively, spilled petroleum products would be directly related to activities in the Sale Area. Spilled petroleum products may result from activities such as drilling and transportation of personnel and materials. Petroleum products may persist in aquatic environments for years after a spill or leak. Petroleum products in the water column can affect the ability of fish to take up oxygen or through ingestion. Oil contaminations can also severely impact egg, larvae, and juvenile survival because they may not have the ability to escape from the contaminated waterbody (Trammell et al. 2015).

The effects of oil spills on fish and their habitat are based on the timing and location of the spill. Summer spills when the water is not frozen are more likely to affect fish than a spill onto ice. A spill into a lake is likely to have longer lasting effects than a spill into a stream or river which could lead to effects on a larger area due to its mobility. Spills occurring farther upstream in a watershed also place more freshwater habitat at risk than those that occur in lower reaches or along the coast where the contaminants are more readily diluted with the higher volumes of water. Oil spills along or near the coast would likely disperse and degrade faster due to stronger currents and wind. However, if oil from a spill along the coast remains in the water when the water begins to freeze, it could migrate upstream into rivers during the winter due to saltwater intrusion (EPPR 1998).

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have effects on fish populations, although the direct, indirect, and cumulative impacts to fish and fish habitats are expected to be localized and minor. Measures in this best interest finding, along with regulations imposed by other state, federal and local agencies are expected to avoid, minimize, and mitigate those potential effects. AS 16.05 requires protection of documented anadromous streams from disturbances associated with development. Any water intake structures in fish bearing or non-fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must utilize fish screening devices approved by the ADF&G. Use of continuous fill causeways is prohibited. Disposal of wastewater into water bodies is prohibited unless authorized by an APDES permit. A complete listing of mitigation measures can be found in Chapter Nine. Chapter Seven also provides information on solid waste and wastewater disposal in the Sale Area.

10. Reasonably Foreseeable Cumulative Effects on Bird Habitats and Populations

a. Potential Effects on Bird Habitat and Populations

In arctic environments, the most notable effects of oil and gas activities are physical disturbances. Post-disposal oil and gas activities have the potential to affect birds through habitat loss, alteration, and disturbance resulting from vehicle noise, dust deposition, thermokarst, attraction to habitats altered by thermokarst, or disturbance from increased aircraft noise or visual stimuli. Activities such as seismic surveys, road and other construction activities, and ongoing vehicle and human traffic may alter landscapes and habitat. Threatened and endangered species are known to occur in the Sale Area. Overall impacts to threatened and endangered species are expected to be minor, localized, and negligible on a population basis.

Some bird species, during periods of nesting, molting, and staging, are sensitive to activities associated with development. Generally, responses to industrial activities depend on the species exposed, the physiological or reproductive state of the birds; distance from the disturbance; type, intensity, and duration of the disturbance; and possibly other factors (MMS 1996). Potential impacts are more likely to occur after the exploration phase, as few resident species are present during winter when exploration occurs. Potential impacts include habitat loss, barrier to movement, disturbance during nesting and brooding, change in food abundance and availability, and oil spills.

i. Disturbance

Human activities such as air traffic and foot traffic near nesting waterfowl, shorebirds, and seabirds, could cause some species to temporarily abandon important nesting, feeding and staging areas. Birds have keen eyesight, and even slight movements may cause adults to abandon young hatchlings. A study of effects of aircraft on molting brant in the Teshekpuk Lake area (Derksen et al. 1992) concludes that helicopters, and to a lesser extent fixed-wing aircraft, cause serious disturbance. However, disturbance does not translate into a population reduction. Some species, such as tundra swans, are particularly sensitive to humans on foot, and may abandon their nests when humans approach within 500–2000 meters of the nest (MMS 1996).

ii. Seismic

No bird species are known to have been significantly affected by the high-energy impulses produced by seismic air guns. A 2001 Beaufort Sea study of molting male, long-tailed ducks before, during, and after seismic testing found no effect of the activity on either movements or diving behavior. Nor did it affect site fidelity. The authors noted that logistical and ecological factors limited their ability to detect more subtle disturbance effects (Lacroix et al. 2003).

iii. Displacement and Habitat Loss

Siting of onshore facilities, such as drill pads, roads, airfields, pipelines, housing, oil storage facilities, and other infrastructure, could eliminate or alter some preferred bird habitats such as wetlands. Onshore pipeline corridors may include a road and associated impacts from traffic noise and dust may deter nesting in the immediate vicinity. The construction of offshore pipelines or re-supply activities could have temporary effects on the availability of food sources of some birds within a mile or two of the construction area due to turbidity and removal of prey organisms along the pipeline route. Impacts to waterfowl and shorebird populations are not likely to persist after development phase activities are completed (MMS 1996).

After facilities are built, the direct alteration of habitat displaces individuals that can no longer nest in the area covered by the facility. Additional birds may avoid the area adjacent to the facility due to disturbance effects. The effects of such direct displacement of individuals on the overall population dynamics of a given species is not known because it is poorly understood how much nesting habitat availability on the North Slope may be a limiting factor for overall populations (NRC 2003).

iv. Construction

Construction activities may result in a permanent loss of some bird habitat. Gravel mining and placement for the construction of oil field infrastructure causes loss of habitat for tundra nesting birds. Disturbances caused by construction of gravel roads, pads, and associated human activity have been observed in Pacific loons located in or near oil fields. Gravel mining and placement for the construction of oil and gas infrastructure can lead to loss of habitat for tundra nesting birds. The construction of gravel roads, pads, material sites, and other permanent infrastructure has led to habitat loss for tundra swans. However, studies show that selection of preferred nesting habitat is more important than oil field facility avoidance (Ott et al. 2014).

Water withdrawal from lakes during ice road construction can lower the water level and affect waterfowl and shorebirds that use adjacent habitats, particularly small islands and shoreline areas used for nesting. Changes in water levels depend on the amount of water withdrawn, the volume of the lake, and the recharge rate. Changes to the water regime with impoundments and limiting movement along wetlands may compromise access to food supply.

Development activities that could contribute to cumulative impacts to spectacled and Steller's eiders and their habitat in the Sale Area. Activities involving construction of infrastructure that would directly destroy habitat within the immediate footprint of the project and indirectly affect potential habitats for eiders through disturbance, predation, dust, flooding, changes in natural drainage patterns, thermokarst, snow drifting, and oil and chemical spills. Neither eider has ESA designated critical habitat in the Sale Area and spectacled eider's breeding habitat is offshore, thus development activities would have limited effects on these eiders during breeding and nesting periods.

Overall direct mortality impacts due to collisions with vehicles, aircraft, buildings, pipelines, powerlines, and communications towers were estimated to occur only at very low levels in the North Slope oilfields during present and future developments. Researchers concluded that reduced productivity was the most substantial cumulative impact to bird populations due to oil and gas development activities on the Prudhoe Bay oilfield, and that determination was based on decreased productivity due to increased levels of predators attracted to the development area (NRC 2003).

More recently, a four-year avian study on the Beaufort Coastal Plain further corroborated this concept with evidence of increased predation risk for passerine nests within approximately three miles of oil field infrastructure. When the relationship was tested by avian species individually, not all avian groups, notably semipalmated and pectoral sandpipers, exhibited the same findings (Liebezeit et al. 2009). The inconsistent results among species may have been due to variability in survey year, conditions, or sites.

v. Oil Spills

Direct contact with spilled oil by birds is usually fatal, causing death from hypothermia, shock, or drowning. Oil ingestion from preening oily feathers or consumption of oil-contaminated foods may reduce reproductive ability, and could lead to chronic toxicity through the accumulation of hydrocarbon residues. Oil contamination of eggs by oiled feathers of parent birds significantly reduces egg hatching through toxic effects on chick embryo or abandonment of the nest by parent birds (MMS 2003; NRC 2003). The presence of humans, aircraft, boat and vehicular traffic involved in cleanup activities is expected to cause displacement of nesting, molting, and feeding birds in the oiled areas and contribute to reduced reproductive success of the birds (MMS 2003). The number of birds impacted by a spill would depend on the time of year and the density of local bird populations. Oil entering a river or stream could potentially spread into delta or coastal areas, where impacts to birds could be more severe (BLM 2005).

b. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have effects on birds. Most of these potential effects would likely occur as secondary effects attributed to habitat disturbance. Direct and indirect impacts from disturbance, of many different types, are difficult to measure, but are likely accumulating as the number of developments and the amount of developed area increase. New oil and gas developments have reduced their footprint size and the corresponding direct impacts have been reduced; however, these new developments often rely on aircraft support for transportation of personnel and equipment, potentially increasing disturbance to feeding, nesting, staging and molting birds.

Measures in this best interest finding, along with regulations imposed by other state, federal, and local agencies are expected to avoid or mitigate those effects. If development occurs, some alteration of bird habitat can be expected, particularly with regard to aircraft-related impacts. However, with state and federal oversight, post-disposal oil and gas activities within the Sale Area should not prevent overall bird population levels from remaining at or near current levels. Specific mitigation measures require permanent staffed facilities to be sited, to the extent practicable, outside identified brant, white-fronted goose, snow goose, tundra swan, king eider, common eider, Steller’s eider, spectacled eider, and yellow-billed loon nesting and brood rearing areas. Lessees must comply with the ESA and Migratory Bird Treaty Act as applicable. A complete list of mitigation measures for the Sale Area can be found in Chapter Nine.

G. Reasonably Foreseeable Cumulative Effects on Other Activities

1. Effects on Historic and Cultural Resources

Paleontological resources, the fossil remains of plants and animals, are nonrenewable and are susceptible to adverse impact by both natural and human initiated processes. Historic and cultural resources can be affected by oil and gas activities.

If development occurs, impacts and disturbances to the historic and cultural resources could be associated with installation and operation of oil and gas facilities, including drill pads, roads, airstrips, pipelines, processing facilities, and any other ground disturbing activities. Damage to 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 (BLM 2007; DOI 1987).

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 (DOI 1987). The 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).

For example, historic and cultural resources may be encountered during field-based activities, and these resources could be affected by accidents such as an oil spill. Following the *Exxon-Valdez* oil spill, 24 archaeological sites experienced adverse effects including oiling of the sites, disturbance by clean-up activities, and looting and vandalism. Monitoring of the sites over a seven-year period indicated that vandalism continued to be a minor problem, and that although some sites were initially badly damaged by oiling, residual oil does not appear to be contaminating known sites, and sites are now considered to be recovered (EVOSTC 2017).

Cultural wellbeing in communities plays an important role in overall health and stability of sociocultural systems. Rapid social, cultural, economic, and environmental changes in Inuit communities can adversely affect community health through changes in living conditions and ways of life. Maintaining cultural values and a positive cultural identity has been linked to positive health outcomes in rural communities in Alaska (NSB 2012).

Various mitigation measures used to protect archaeological sites during spill cleanups include avoidance, site consultation and inspection, onsite monitoring, site mapping, artifact collection, and cultural resource awareness programs (Bittner 1996). Measures in this best interest finding, along with other regulatory protections, are expected to mitigate those potential effects.

H. Mitigation Measures and Other Regulatory Protections

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 2017). The NSB also has specific requirements under Title 19 of the Municipal Code.

However, from a cumulative perspective, more cultural sites have been disturbed and cultural material removed from the North Slope in general and the Sale Area in particular as the result of scientific studies than has been destroyed or removed through unauthorized collection resulting from oil and gas exploration and development or other construction-related activities (BLM 2012;

NRC 2003). As in the past, assessments to identify and protect cultural resources prior to the initiation of surface disturbing activities will be a major factor in reducing future cumulative adverse impacts to cultural resources.

Because of the varying circumstances of occurrence surrounding the location and vulnerability of cultural resources, the significance of future impacts to the resource is difficult to assess in terms of the cumulative case. However, if the protections that are in-place carry forward, then the cumulative impact would be expected to be minor within the Sale Area. A complete listing of mitigation measures is in Chapter Nine.

1. Effects on Access and Local Transportation

The Sale Area and adjacent lands are located within the jurisdictions of several entities, which have varying authorities over oil and gas development activities on those lands. These include the State of Alaska for state land in the Sale Area, jointly owned lands with the Arctic Slope Regional Corporation (ASRC) as described in the 1991 Settlement Agreement discussed in Chapter Three, the Bureau of Land Management (BLM) for federal land (including both BLM-managed surface and subsurface, as well as land that has been selected by Kuukpik Corporation but not yet conveyed), the NSB, Kuukpik Corporation as a surface land owner, and ASRC as the owner of the subsurface rights under Kuukpik Corporation land. Cumulative impacts to sociocultural systems include possible tension among community and regional institutions including the Native Village of Nuiqsut, the City of Nuiqsut, Kuukpik Corporation, ASRC, BLM, and the NSB regarding their respective roles and jurisdiction over development activities on the North Slope.

The Sale Area and adjacent lands have undergone changes with respect to local transportation since the 1970s. The community of Nuiqsut was reestablished in 1973, and soon after, the TAPS was built and production at Prudhoe Bay began. The reestablishment of the community and oil development in Prudhoe Bay and the Sale Area in general have included the development and construction of roads, airports, and other supporting infrastructure in the previously undeveloped area.

Continued construction of additional roads in the Sale Area to benefit oil and gas development would impact communities in positive and negative ways. Some negative impacts of permanent roads linking distant communities to the Sale Area would be permanent changes to the characteristic of the landscape, introduction of public access into currently non-easily accessible areas, increase in the overall noise level, and increase in the viability of further development in and surrounding the Sale Area with cumulative impacts in the Nuiqsut area being long-term with both localized and regional benefits (NSB 2005).

Independent of oil and gas development, DNR is spearheading the state’s Arctic Strategic Transportation and Resources (ASTAR) program. ASTAR is analyzing conceptual infrastructure corridors that could meet the needs of the North Slope communities. Of relevance to the Sale Area is the potential transportation and utility corridors that would connect Point Hope, Point Lay, Wainwright, Atqasuk, and Utqiaġvik with Nuiqsut and Anaktuvuk Pass with Deadhorse by connecting with existing permanent roadways. ASTAR is in its preliminary stages, and it is anticipated that effects from road construction and transportation corridors could influence future development of oil and gas resources as has been the pattern from previous development (ASTAR 2017).

An increase in permanent road access may be beneficial to future oil and gas exploration and development in and adjacent to the Sale Area depending on the location of the oil and gas resource. As noted above, additional revenue is allocated to NSB communities with additional oil and gas properties producing hydrocarbons. Permanent roads system could benefit residents of Nuiqsut seeking access to traditional subsistence areas now limited to travel by off-road vehicle or snowmachine while access may adversely impact the ability to harvest subsistence resources in the immediate area of the road and other facilities (NRC 2003).

As more roads are constructed in the Sale Area, NSB residents have voiced concerns. Road construction and more traffic increasing competition for and diversion of subsistence resources and pressure on wildlife populations are concerns. Other concerns are diminishing water and air quality, increased social ills and safety issues, vegetation damage and erosion, and more noise and disturbance (NSB 2014). Lease mitigation measures, NSB requirement for new roads under the Title 19 zoning code, and stipulations on permits will help reduce these potential effects.

2. Effects on Recreation and Tourism

Tourism may be characterized as business tourism, pleasure, and vacation tourism, and visiting friends and relatives. Of these, business and vacation tourism are the types most affected by oil and gas development. There would be very little, if any, effects on business travel and visiting in communities in or near the Sale Area. Outdoor recreation and vacationing in communities in or near the Sale Area is common, but it is not expected oil and gas activities would have an effect on outdoor recreation other than mild disturbances. It is assumed oil and gas activity areas would be generally avoided by visitors.

A major spill could have an impact on recreation as it has in other parts of Alaska and the United States. An analysis of the 2010 BP Macondo oil spill in the Gulf of Mexico, which included 11 case studies of other oil spills, concluded the average range of oil spill impacts to tourism was 12–28 months (USTA 2010). An analysis of the effects of the 1989 *Exxon-Valdez* oil spill showed that 60 percent of the tourism providers had cancellations and that visitor inquiries fell 55 percent one year after the spill. Labor shortages became a problem as people worked on the cleanup, and business for accommodations providers and airlines increased. One year later, 37 percent of tourism companies said business was not affected, 30 percent said business was slightly or moderately affected, and 12 percent were significantly affected (AOGA 2014). It is highly unlikely an oil spill of the magnitude of the spills noted above would occur in the Sale Area; however, containment and control of spills of moderate size may have impacts on recreational users.

I. Reasonably Foreseeable Fiscal Effects of the Lease Sale and Subsequent Activity on the State and Affected Municipalities and Communities

This section discusses the statewide and local fiscal effects of leasing activities. Leasing and subsequent activity may generate income for state government, with additional benefits that include increased revenue sharing, creation of new jobs, and indirect income multiplier effects. Fiscal effects may be statewide and local.

Crude oil production remains a key revenue generator for the State of Alaska, and production forecasting is an important part of the state's overall fiscal planning. Previous years of forecasting production have provided useful information to the public on this valuable state resource and guidance to decision makers within and outside the state. Lower oil prices make the task of planning for the state's future even more critical.

1. Fiscal Effects on the State

a. Unrestricted Revenue

Alaska's economy and state government operations depend heavily on revenues related to oil and gas production. Oil and gas lease sales generate income to state government through royalties, bonuses, rents, interest, production taxes, petroleum corporate income taxes, and petroleum property taxes. Between Statehood in 1959 and FY2016, oil related revenues totaled $177.7 billion (real 2016 dollars). The oil and gas industry paid over $2 billion in taxes and royalties, with $1.6 billion paid to state government and $447 million paid to local governments in FY 2016. From the $1.6 billion paid to state government, $1.1 billion of that being allocated into the Unrestricted General Fund (UGF). Total oil revenue for FY2016 was down from almost $2.4 billion in FY2015 (McDowell Group 2017).

In October 2017, the Alaska Department of Revenue (ADOR) released their preliminary 10-year revenue forecast for revenue deposited into the UGF based on the forecast of Alaska North Slope oil prices and oil production forecasts. UGF is forecast to be $1.8 billion, for FY2018, $2.0 billion in FY2019, and $2.8 billion by the end of the forecast period in FY2027. This is based on a forecast of Alaska North Slope oil prices averaging $54.00 per barrel for FY2018, climbing to $75.00 per barrel by FY2027 (ADOR 2017b). These projections are adjusted annually through ADOR revenue forecasts.

i. Lease Bonuses and Rentals

Lease bonuses and lease rentals are two components that contribute revenue to the state. Bonus bids are cash payments received by the state, usually at a lease sale, to obtain of an oil and gas lease. Normally, the state's sale terms establish the bonus payment as the bid variable so that the bidder offering the highest bonus bid wins the lease being offered. Since 2000, annual revenues from lease bonus payments have ranged from as low as about $2.5 million in 2005 to as high as $64.9 million in 2014 (ADOR 2015).

Each lease requires an annual rental payment. Lease rentals are periodic cash payments received by the state to maintain an oil and gas lease and the rights granted under it. Currently, the state receives approximately $20 million annually in lease rental payments.

The lessee must pay the rent in advance and receives a credit on the royalty due under the lease for that year equal to the rental amount. The rental rate may not be the same for each lease sale over the 10-year term of this best interest finding, and will be published in the pre-sale notice as discussed in Chapter Two.

ii. Royalties

Royalty payments are based on the value and volume of the oil and gas removed from the state-leased land and the lease's royalty rate. Royalties, including bonuses, rents and interest on petroleum production, totaled $840.3 million in FY2016. This revenue represented 76 percent of unrestricted oil and gas revenue and 52 percent of total and unrestricted and restricted oil and gas revenue (McDowell Group 2017). As of October 2017, funds received from oil and gas leases including royalties, bonuses, rents and interest on petroleum production was over $750 million for the calendar 2017 year to date (ADNR 2017).

iii. Oil and Gas Production Taxes

On the North Slope, an annual tax is levied on the net value of oil and gas production (AS 43.55) with a tax floor based on the gross value. For North Slope producers, the current tax rate is 35 percent of the net value of oil and gas with a minimum tax floor ranging 0–4 percent of the gross value depending on the price of ANS crude. Net value is equal to gross value at the lease minus the costs of production. Producers may also apply certain per-barrel tax credits to reduce their tax liability to the minimum tax floor or potentially zero. Unused costs can be carried forward to reduce tax liability in future years. To encourage new oil and gas production, net value is calculated with a 20 percent reduction in the gross value for the first seven years of production. In FY2016, the production tax generated $176.8 million in state revenue (McDowell Group 2017).

iv. Corporate Income Tax

Corporate income taxes must be paid by C-corporations in the state for all taxable worldwide income apportioned to the State based on property, production, and sales within the state (AS 43.20). According to the ADOR, in SFY2016, corporate income tax revenue was negative (−$58.8 million) due to large refunds of prior-year estimated taxes and low estimated taxes for FY2016. ADOR estimates corporate income tax will be approximately $96.4 million in FY2017 and $235.4 million in FY2018 (ADOR 2016).

v. Property Tax

Alaska's oil and gas property tax is levied on the value of taxable exploration, production, and pipeline transportation property at a rate of two percent of the assessed value. In FY2016, this tax generated $112 million for the state with the remaining $447 million paid to local governments. For FY2017, ADOR has forecasted oil and gas property tax to be paid to the state to be approximately $115.8 million and $109.7 million for FY2018 (ADOR 2016).

vi. Oil Conservation Surcharge

The Oil and Hazardous Substance Release Prevention and Response Fund was created in 1986 and is intended to be a source of funds that can be drawn upon in the event of a release of a hazardous substance for the abatement of damages (ADOR 2016). Under AS 43.55.201–300, the fund is maintained through a per-barrel tax, and is separated into two accounts: one supporting response to a hazardous release and another that supports the prevention of hazardous releases which primarily funds a division at the ADEC (ADOR 2016; McDowell Group 2017). In 2015, the legislature added funding to the Spill Prevention and Response program through a surcharge on refined fuel sales in the state (ADOR 2016).

b. Restricted Revenue

A portion of Alaska's oil and gas are revenues restricted and designated for specific uses. In FY2016, of the $1.6 billion generated from oil and gas activity paid to the state, $518 million, 24 percent, was restricted revenue. This component represented 8.9 percent of all state revenue. This revenue is placed in several funds including the Alaska Permanent Fund, the Public School Trust Fund, and the Constitutional Budget Reserve Fund. Additionally, the state is entitled to 50 percent of bonuses, rents, and royalties associated with leasing of lands in the NPR-A (ADOR 2016; McDowell Group 2017).

i. Alaska Permanent Fund

The Alaska Constitution was amended by public referendum in 1976, dedicating at least 25 percent of all mineral lease rentals, royalties, royalty sale proceeds, federal mineral revenue sharing payments, and bonuses received by the state to the Alaska Permanent Fund. Revenues from oil and gas activities go into the state's General Fund; however, a portion of the revenue, either 25 percent or 50 percent depending on the lease type, is set aside for the state Permanent Fund. Contributions to the Alaska Permanent Fund are to be invested in income-producing investments authorized by law. The legislature appropriates portions of the Permanent Fund's statutory net income to the Permanent Fund Dividend Fund (Dividend Fund), a sub-fund of the state's general fund created in accordance with AS 43.23.045 and administered by the ADOR. The Dividend Fund is used primarily for the payment of permanent fund dividends to qualified Alaska residents. In addition, the legislature has appropriated a portion of the dividend distribution to fund other activities or operations. As of September 22, 2017, the total fund market value was over $61 billion (APFC 2017).

ii. Public School Trust Fund

Established under AS 37.14.110–170, the Public School Trust Fund originally consisted of income from the sale or lease of land granted by an Act of Congress on March 15, 1915, but is now primarily funded by a 0.5 percent royalty on receipts connected with the management of State of Alaska Lands (AS 37.14.150), including revenue generated through royalties, mineral lease rentals, the sale of surface rights, and other activity. The principal of the fund, and all capital gains and losses thereon, are perpetually retained in the fund (AS 37.14.110) and the remaining net income of the fund must be used for the State public school program (AS 37.14.140). On September 30, 2017, the fund's principal market value was over $650 million, an increase from the principal fund market value of $573 million in FY2016 (ADOR 2017b).

iii. Constitutional Budget Reserve

The Constitutional Budget Reserve Fund (CBRF) was established November 6, 1990 when voters approved adding Section 17 to Article IX of the Constitution of the State. All money received by the State after July 1, 1990, through resolution of disputes about the amount of certain mineral-related income, must be deposited in the CBRF. The Legislature may, under certain conditions, appropriate funds from the CBRF to fund the operations of state government (ADOR 2017a).

On September 30, 2017, the fund had a market value of over $3.8 billion, a significant decrease from $7.3 billion in FY2016 (ADOR 2017a). In SFY2016, the oil and gas industry paid $119.1 million into the CBRF, and the fund generated $138.3 million from investment activities.

iv. NPR-A Royalties, Rents, and Bonuses

Revenues from royalties, rents and bonuses associated with leasing and production in the NPR-A are split equally between the State of Alaska and United States Government. This restricted revenue first goes to municipalities to minimize impacts associated with NPR-A development in the form of grants administered by Alaska Department of Commerce, Community and Economic Development. Any remaining funds are allocated in accordance with State of Alaska royalty revenue distributions. In SFY2016, $1.8 million was collected from leasing activity and oil production on NPR-A lands, supporting local government operations, youth programs, and infrastructure projects (McDowell Group 2017).

c. Employment

Estimates of the statewide impacts of oil and gas industry related jobs and wages can vary widely as there is no standard definition of what constitutes the oil and gas industry or consistent survey methodology used in all assessments. For example, a study by the McDowell Group (2017) used a broader definition of the industry than one typically used for government employment statistics. Government-published statistics for oil and gas employment in Alaska include jobs in companies classified under “oil and gas extraction,” “drilling oil and gas wells,” and “support activities for oil and gas operations.” (McDowell Group 2017).

Employment and wage data for 2016 were analyzed for 14 businesses that comprised the group of “Primary Companies”. The Primary Companies included: Alyeska Pipeline Service Company, BlueCrest Energy Inc., BP Alaska, Caelus Energy, LLC, Chevron Corporation, ConocoPhillips, ExxonMobil, Furie Operating Alaska, Glacier Oil & Gas Corporation, Great Bear Petroleum, Hilcorp Energy Company, Petro Star Inc., Shell Exploration & Production Company, and Tesoro Alaska. The 14 firms that comprise the group of Primary Companies directly employed 5,035 workers in Alaska in 2016, including 4,275 Alaska residents, 85 percent of Primary Company employees. These employees received $936 million in wages; Alaska residents received $749 million, 80 percent of the total. Economic impact modeling indicates these subsequent cycles of spending supported just under 35,205 indirect and induced jobs in Alaska. Combining direct, indirect, and induced impacts, the oil and gas industry in Alaska supported 45,575 jobs and $3.1 billion in annual payroll in 2016. This estimate does not include jobs and income in Alaska stemming from the expenditure of state and local government oil-related taxes and royalties paid by the oil industry. For every Primary Company job, there are nine more jobs supported by Primary Company activity in Alaska, and 13 more jobs are supported by oil-related taxes and royalties (McDowell Group 2017).

i. Workforce Development

The workforce that supports Alaska’s oil and gas industry requires that adequate training opportunities exist and that knowledge of the skills needed are available to those helping guide workforce development. To fill the high demand, Alaska must provide avenues of workforce development that accommodate high paying jobs found in the oil and gas industry. This will put

Alaska residents to work in these jobs and provide industry confidence that Alaskans can substantially help meet future labor demands.

Alaska's trade apprenticeship programs are critical to meeting the needs of the oil and gas industry's need for skilled workers in Alaska's oil and gas fields. There are more than 2000 apprentices being trained in five training centers between Fairbanks and Juneau (ADOR 2015). According to the Alaska Department of Labor and Workforce Development (AKDOL&WD), the benefits of registered apprenticeship include higher employment rates, higher wages, and higher rates of Alaska hire. Between 2004 and 2014, new registration in apprenticeship programs had increased by over 50 percent. Approximately 88 percent of the people registered in Alaskan apprentice programs were Alaska residents, therefore the vast majority of their wages are spent in Alaska. Approximately 11 percent of apprentices work in the natural resources and mining industry; however, the other industries that have active apprentice programs including construction, trade, transportation, and utilities, provide support for the oil and gas industry (Kreiger 2016).

There are several apprenticeship programs available in Alaska for various trades and specialties. Some of these programs include the Alaska Apprenticeship Training Coordinators Association which offers training for apprentices in the construction trade; Alaska Works for pre-apprenticeship training specializing in training women and military personnel for apprenticeship opportunities; Associated Builders and Contractors Inc. for specialized construction trades; Alaska Vocational Technical Center, Alaska's institute of technology; Alaska Health Care Apprenticeship Consortium; and two programs for maritime training including the Paul Hall Center for Maritime Training and Education, and the Alaska Maritime Apprenticeship Program (AATCA 2017; Alaska Works Partnership 2017; ABC 2017; AVTEC 2017; AHCAC 2017; SIU 2017; AMAP 2017).

ii. Apprenticeships

In November 2015, Alaska Governor Bill Walker signed Administrative Order 278 (AO 278), which requires DNR to consider ways to encourage lessees to employ apprentices for work performed on the leased area. The goal of AO 278 is to require apprentice level employees to perform at least 15 percent of the total work hours. Lessees are encouraged to employ apprentice level workers to the extent they are qualified and available.

Apprentice hiring has many benefits to oil and gas companies employing workers in Alaska. A company's workforce is strengthened through reduced turnover of employees which reduces expenditures for retraining and onboarding, increases productivity and knowledge transfer, and improves safety records. It is also important to note oil and gas companies may create or sponsor suit-to-fit apprenticeship programs for the company's desired trade or service.

In the last 10 to 15 years, many new companies have become leaseholders in the state. Alaska provides world-class resource potential and a well-trained workforce familiar with the oil and gas industry. Lessees are often familiar with the resource potential, but greater familiarity with apprenticeship as a workforce development tool would benefit any companies looking to succeed in Alaska. DNR will convey information to new and existing lessees about apprenticeship options in Alaska.

In consultation with the AKDOL&WD, DNR has increased its understanding of the apprenticeship programs in Alaska and the benefits of hiring apprentices. DNR has included a mitigation measure encouraging apprentice hiring on projects on state oil and gas leases. It is also required that plan of operations application include proposals detailing how the lessee will comply with attempting to employee apprentices to perform at least 15 percent of total work hours in the lease area.

2. Fiscal Effects on Municipalities and Communities

Oil and gas exploration, development, and transportation have been the primary industry and financial source for the North Slope communities since the late 1960s. The oil and gas industry and the associated support industries, including the government sector, have provided the majority of the jobs to the residents of the region in that timeframe as well. As residents have both benefited and grown accustomed to the result of modern capital development on the North Slope, the NSB has transformed to a mixed cash subsistence economy. In addition to the petroleum industry, the NSB has become a dominant economic organization on the North Slope. The NSB taxes the oil and gas facilities and uses the revenues to provide education and a wide array of other public services within its boundaries. The economy and tax base is rooted in the oil and gas industry and it remains strong today. The total assessed value was $21.3 billion for the NSB in FY 2016 (NSB 2016).

a. Property Taxes for the NSB

Property tax revenues from oil and gas properties typically provide over 90 percent of the taxes levied by the NSB. The revenue has nearly doubled since from 2006 to 2015 due to more increases in assessed value of properties and more property to be taxed (NSB 2015a). The oil and gas industry paid $347.5 million in property taxes to the NSB during the 2016 fiscal year (McDowell Group 2017).

It has been assumed that decline in production of the North Slope oil fields would result in a decline in property tax revenues. However, as new discoveries are made and additional projects come online, it is anticipated that the increased level of activity will supplement the NSB tax base, the state's operating budget, and debt reimbursement (NSB 2016).

b. Other Revenue

Alaska Native corporations and the shareholders may benefit from lease sales and any development that results. For example, Kuukpik Corporation owns surface lands within the Sale Area, and the Arctic Slope Regional Corporation (ASRC) owns certain subsurface minerals. Kuukpik Corporation enters into surface access agreements with oil and gas companies operating on its land and collects revenues. Royalties and other oil and gas revenue are paid to ASRC from production and rent where ASRC is the mineral owner in the Sale Area and the NPR-A. Oil and gas revenue from ASRC lands, 70 percent of which are paid to the other 12 Alaska Native Corporations in accordance with section 7(i) of Alaska Native Claims Settlement Act, eventually reach corporation shareholders in the form of shareholder dividend payment (NSB 2015b).

In addition, revenues from exploration and development of oil and gas resources in the Sale Area and elsewhere on the North Slope have added economic stability to local communities. The cumulative economic impacts also apply at the local community level. Although smaller scale, the economic ramification can be of high intensity, long-term, localized, and major since communities adjacent to the Sale Area receive revenue from oil and gas through land ownerships used by industry, distribution of special funds unique to those leases, appropriations for a variety of services from state government, and impact funds from the State's share of revenues collected from development on federal land. Continuing or expanding those opportunities are dependent on Sale Area oil and gas revenues.

i. Employment

There were approximately 14,000 jobs reported in the NSB in 2016. Approximately 75 percent (or 10,500) of those jobs were in the Prudhoe Bay area. While a very large number of oil and gas industry jobs are based in the NSB, very few of these workers reside in the Borough. The North Slope oil industry infrastructure and work sites are self-contained and hundreds of miles away from most of the Borough’s resident population. Because most workers reside outside of the Borough, employment and wage data are often calculated by place of work (McDowell Group 2017).

A report commissioned by the Alaska Oil and Gas Association identifies 14 companies operating in Alaska as Primary Companies for purpose of analysis of the oil and gas industry’s economic impact on Alaska. Primary Companies in the NSB provided approximately 1,845 jobs and accounted for $399 million in annual wages during 2016. Oil and gas support services companies operating in the NSB provided 5,590 jobs and accounted $512 million in annual wages. Of these positions, Alaska residents held an estimated 3,410 (61 percent) of these positions and earned $315 million (62 percent) in wages (McDowell Group 2017).

Primary Companies and oil and gas support services companies supported employment for approximately 55 NSB residents with about $4 million in wages and an additional 1,790 jobs generating $101 million in wages are also connected to oil and gas industry activity in and around the Sale Area (McDowell Group 2017). As exploration occurs, employment opportunities would be added to the state and regional economy. These jobs would not be limited to the oil and gas industry, but would spread throughout the trade, transportation, service, and construction industries.

c. Mitigation Measures and Other Regulatory Protections

Although post-disposal oil and gas activities could potentially have effects on boroughs and communities in or adjacent to the Sale Area, measures in this best interest finding, along with other regulatory protections, are expected to mitigate potentially negative effects. Positive effects are expected on local governments and economies, employment, personal income, reasonable energy costs, and opportunities for industrial development. Lessees are encouraged to employ local Alaska residents and contractors, and apprentice labor, to the extent they are available and qualified. Lessees must submit, as part of the plan of operations, a proposal detailing the means by which the lessee will comply with the mitigation measures. The plan must include a proposal with a description of the operator’s plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors, per Section 31 of the lease. A complete listing of mitigation measures can be found in Chapter Nine.

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Chapter Nine: Mitigation Measures

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Operations will be conditioned by mitigation measures that are attached to any leases issued and are binding on the lessee. These measures were developed to mitigate potential effects of lease-related activities, considering all information made known to the director. Additional measures may be imposed when the lessee submits a proposed plan of operations (11 AAC 83.158(e) and 83.346(e)) for exploration, production, development, or transportation uses, or in rights-of-way for other pipelines. The director may consult with local government organizations and other agencies in implementing the mitigation measures below. Lessees are subject to applicable local, state, and federal laws and regulations, as amended.

The director may grant exceptions to these mitigation measures upon a showing by the lessee that compliance with the mitigation measure is not practicable and that the lessee will undertake an equal or better alternative to satisfy the intent of the mitigation measure. Requests and justifications for exceptions must be included in the plan of operations application as specified by the application instructions, and decisions of whether to grant exceptions will be made during the plan of operations review.

A. Mitigation Measures

1. Facilities and Operations

a. Oil and gas facilities, including pipelines, shall be designed using industry-accepted engineering codes and standards. Technical submittals to the Division of Oil and Gas (DO&G) that reflect the "practice of engineering," as defined by AS 08.48.341, must be sealed by a professional engineer registered in the State of Alaska.

b. A plan of operations shall be submitted and approved before conducting exploration, development, or production activities in accordance with 11 AAC 83.

c. Facilities shall be designed and operated to minimize sight and sound impacts in areas of high residential, recreational, and subsistence use and important wildlife habitat.

d. The siting of facilities, including roads, airstrips, and pipelines, is prohibited within one-half mile of the coast as measured from the mean high water mark and 500 feet of all fish bearing waterbodies.

e. Notwithstanding (d) above, the siting of facilities is prohibited within one-half mile of the banks of the Colville, Canning, Sagavanirktok, Kavik, Shaviovik, Kadleroshilik, Echooka, Ivishak, Kuparuk, Toolik, Anaktuvuk and Chandler Rivers as measured from the ordinary high water mark. Facilities may be sited, on a case-by-case basis, within the one-half mile buffer if the lessee demonstrates that siting of such facilities outside this buffer zone is not feasible or prudent, or that a location within the buffer is environmentally preferable.

f. No facilities will be sited within one-half mile of identified Dolly Varden overwintering and/or spawning areas on the Canning, Shaviovik, and Kavik rivers. Notwithstanding the previous sentence, road and pipeline crossings may only be sited within these buffers if the lessee demonstrates to the satisfaction of the director and Alaska Department of Fish and Game (ADF&G) in the course of obtaining their respective permits, that either (1) the scientific data indicate the proposed crossing is not within an overwintering or spawning area; or (2) the proposed road or pipeline crossing will have no significant adverse impact to Dolly Varden overwintering or spawning habitat.

g. Impacts to important wetlands shall be minimized to the satisfaction of the director, in consultation with ADF&G and Alaska Department of Environmental Conservation (ADEC). The director will consider whether facilities are sited in the least sensitive areas.

h. Exploration roads, pads, and airstrips shall be temporary and constructed of ice. Use of gravel roads, pads, and airstrips may be permitted on a case-by-case basis by the director, in consultation with Division of Mining, Land, and Water (DMLW) and ADF&G.

i. Road and pipeline crossings shall be aligned perpendicular or near perpendicular to watercourses.

j. Pipelines

    i. Shall use existing transportation corridors and be buried where soil and geophysical conditions permit.

    ii. In areas with above ground placement, pipelines shall be designed, sited, and constructed to allow for the free movement of wildlife and to avoid significant alteration of caribou and other large ungulate movement and migration patterns.

    iii. At a minimum, above ground pipelines shall be elevated seven feet, as measured from the ground to the bottom of the pipeline, except where the pipeline intersects a road, pad, or a ramp installed to facilitate wildlife passage. A lessee shall consider snow depth in relation to pipe elevation to ensure adequate clearance for wildlife.

    iv. Pipelines and gravel pads shall facilitate the containment and cleanup of spilled fluids.

k. Causeways and docks shall not be located in river mouths or deltas. Approved causeways shall be designed, sited, and constructed to prevent significant changes to nearshore oceanographic circulation patterns and water quality characteristics (e.g., salinity, temperature, suspended sediments) that result in exceedances of water quality criteria, and must maintain free passage of marine and anadromous fish.

l. Artificial gravel islands and bottom founded structures shall not be located in river mouths or active stream channels on river deltas, except as provided for in (m) below.

m. Each proposed structure will be reviewed on a case-by-case basis. Causeways, docks, artificial gravel islands and bottom founded structures may be permitted if the director, in consultation with ADF&G and ADEC, determines that a causeway or other structures are necessary for field development and that no practicable alternatives exist. A monitoring program may be required to address the objectives of water quality and free passage of fish, and mitigation shall be required where significant deviation from objectives occurs.

n. 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 and any non-state surface owner, determines that such removal and rehabilitation is not in the state's interest.

o. Material sites required for exploration and development activities shall be:

  i. restricted to the minimum necessary to develop the field efficiently and with minimal environmental damage,

  ii. where practicable, designed and constructed to function as water reservoirs for future use, and

  iii. located outside active floodplains of a watercourse unless the director DMLW, after consultation with ADF&G, determines that there is no practicable alternative, or that a floodplain site would enhance fish and wildlife habitat after mining operations are completed and the site is closed.

p. The director may include plan stipulations if necessary to reduce or eliminate adverse impacts to fish and wildlife or to protect the environment.

2. Fish Wildlife and Habitat

a. The lessee shall consult with the North Slope Borough (NSB) before proposing the use of explosives for seismic surveys. The director may approve the use of explosives for seismic surveys after consultation with the NSB.

b. Any water intake structures in fish bearing or non-fish bearing waters shall be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must use fish screening devices approved by ADF&G.

c. Removal of snow from fish-bearing rivers, streams, and natural lakes shall be subject to prior written approval by ADF&G. Compaction of snow cover overlying fish-bearing waterbodies is prohibited except for approved crossings. If ice thickness is not sufficient to facilitate a crossing, then ice or snow bridges may be required.

d. Bears:

  i. Brown bears

    A. A lessee must consult with ADF&G before commencing any activities to identify the locations of known brown bear den sites that are occupied in the season of proposed activities.

    B. Exploration and production activities shall not be conducted within one-half mile of occupied brown bear dens unless alternative mitigation measures are approved by ADF&G.

    C. A lessee who encounters an occupied brown bear den not previously identified by ADF&G shall report it to the Division of Wildlife Conservation, ADF&G, within 24 hours. The lessee will avoid conducting mobile activities one-half mile from discovered occupied dens unless alternative mitigation measures are approved by the director, with concurrence from ADF&G. Non-mobile facilities will not be required to relocate.

ii. Polar bears

A. Consultation with the US Fish and Wildlife Service (USFWS) is required prior to commencement of any activities as required by the Endangered Species Act, and also to identify the locations of known polar bear den sites.

B. Operations shall avoid known polar bear dens by at least one mile.

C. A lessee who encounters an occupied polar bear den not previously identified by USFWS shall report it to the USFWS within 24 hours and subsequently avoid the new den by at least one mile.

D. If a polar bear should den within an existing development, off-site activities shall be restricted to minimize disturbance.

iii. For projects in proximity to areas frequented by bears, the lessee is required to prepare and implement a human-bear interaction plan designed to minimize conflicts between bears and humans. The plan shall include measures to:

A. minimize attraction of bears to facility sites;

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

C. warn personnel of bears near or on facilities and the proper actions to take;

D. if authorized, deter bears from the drill site;

E. provide contingencies in the event bears do not leave the site;

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

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

e. Permanent, staffed facilities shall be sited to the extent practicable outside identified brant, white-fronted goose, snow goose, tundra swan, king eider, common eider, Steller’s eider, spectacled eider, and yellow-billed loon nesting and brood rearing areas.

f. The director, in consultation with ADF&G, may impose additional and seasonal restrictions on activities located in, or requiring travel through or overflight of, important caribou or other large ungulate calving and wintering areas during the plan of operations approval stage.

3. Subsistence, Commercial, and Sport Harvest Activities

a. Lease-related use will be restricted if necessary to prevent unreasonable conflicts with subsistence fish and wildlife harvest activities. 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 the NSB, nearby communities, and native organizations for assistance in identifying and contacting local subsistence users.

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

4. Fuel, Hazardous Substances, and Waste

a. The lessee will ensure that secondary containment is provided for the storage of fuel or hazardous substances and sized as appropriate to container type and according to governing regulatory requirements in 18 AAC 75 and 40 CFR 112. Containers with an aggregate storage capacity of greater than 55 gallons that contain fuel or hazardous substances will not be stored within 100 feet of a waterbody, or within 1,500 feet of a current surface drinking water source.

b. During equipment storage or maintenance, the site must 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.

c. 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.

d. 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 water-borne vessels.

e. All independent fuel and hazardous substance containers must be marked with the contents and the lessee's or contractor's name using paint or a permanent label.

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

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

h. Proper disposal of garbage and putrescible waste is essential to minimize attraction of wildlife. The lessee must use the most appropriate and efficient method to achieve this goal. The primary method of garbage and putrescible waste is prompt, on-site incineration in compliance with State of Alaska air quality regulations. The secondary method of disposal is on-site frozen storage in animal-proof containers with backhaul to an approved waste disposal facility. The tertiary method of disposal is on-site non-frozen storage in animal proof containers with backhaul to an approved waste disposal facility. Daily backhauling of non-frozen waste is required unless safety considerations prevent it.

i. New solid waste disposal sites, other than for drilling waste, will not be approved or located on state property for exploration.

j. The preferred method for disposal of muds and cuttings from oil and gas activities is by underground injection. Drilling mud and cuttings will not be discharged into lakes, streams, rivers, or wetlands. On-pad temporary cuttings storage may be allowed as necessary to facilitate annular injection and backhaul operations. Injection of non-hazardous oilfield wastes is regulated by Alaska Oil and Gas Conservation Commission through its Underground Injection Control Program for oil and gas wells.

5. Access

a. Exploration activities must be supported only by ice roads, winter trails, existing road systems, or air service. Wintertime off-road travel across tundra and wetlands may be approved in areas where snow and frost depths are sufficient to protect the ground surface.

b. Summertime off-road travel across tundra and wetlands may be authorized subject to time periods and vehicle types approved by DMLW.

c. Emergency exceptions may be granted by the director of DMLW, and the director, if it is determined that travel can be accomplished without damaging vegetation or the ground surface on a site-specific basis.

d. Gravel use may be authorized on a site-specific basis if it is determined, after consulting with ADF&G and DMLW, that no practicable alternatives exist for constructing an exploration road or pad in the area south of the boundary described below and depicted in the map below:

Beginning at the NPR-A boundary, from the northeast corner of T 1N, R 2E,

east to the northwest corner of T 1N, R 9E, then
north to the northwest corner of T 4N, R 9E, then
east to the northwest corner of T 4N, R 23E, then
south to the southwest corner of T 4N, R 23E, and then
east along the top of T 3N to the ANWR boundary.

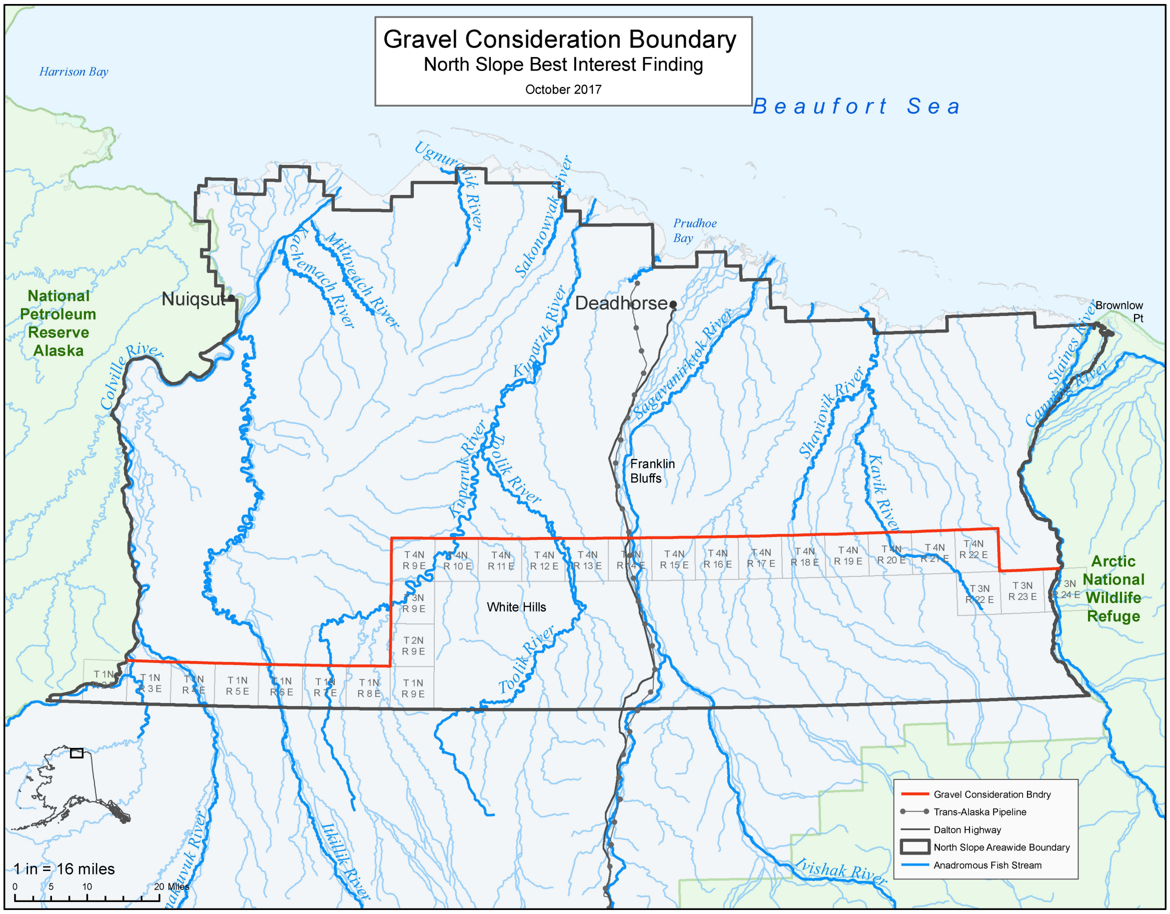

Figure 9.1.—Gravel Consideration Boundary

e. Public access to, or use of, the lease area may not be restricted except within the immediate vicinity of drill sites, buildings, and other related structures. Areas of restricted access must be identified in the plan of operations.

6. Historic, Prehistoric, and Archaeological Sites

a. Before the construction or placement of any structure, road, or facility supporting exploration, development, or production activities, the lessee must conduct an inventory of prehistoric, historic, and archeological sites within the area, including a detailed analysis of the effects that might result from that construction or placement.

b. The inventory of prehistoric, historic, and archeological sites must be submitted to the director and the Office of History and Archeology (OHA) who will coordinate with the NSB for review and comment. If a prehistoric, historic, or archeological site or area could be adversely affected by a lease activity, the director, after consultation with OHA and the NSB, 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 lease operations, the lessee shall report the discovery to the director as soon as possible. The lessee shall make all reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the director, after consultation with the State Historic Preservation Office and the NSB, has directed the lessee on the course of action to take for its preservation.

7. Hiring Practices

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

b. In accordance with Administrative Order 278, the lessee is encouraged to employ apprentice labor to perform at least 15 percent of total work hours, to the extent they are available and qualified, for work performed in the lease area. Lessees shall submit, as part of the plan of operations, a hiring plan detailing the means by which the lessee might incorporate apprentice labor.

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

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

   i. for all personnel including contractors and subcontractors;

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

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

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

B. Definitions

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.

Hazardous substance – As defined under 42 USC 9601 – 9675 (Comprehensive Environmental Response, Compensation, and Liability Act of 1980).

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

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

Plan of operation – A lease plan of operations under 11 AAC 83.158 and a unit plan of operations under 11 AAC 83.346.

Practicable – Feasible in light of overall project purposes after considering cost, existing technology, and logistics of compliance with the mitigation measure.

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

Temporary – No more than 12 months.