U.S. Department of the Interior
Bureau of Land Management

Willow Master Development Plan

Environmental Impact Statement

DRAFT

Volume 3: Appendices B through E.12

August 2019

Prepared by:
U.S. Department of the Interior
Bureau of Land Management

In Cooperation with:
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Coast Guard
U.S. Department of Transportation
Native Village of Nuiqsut
Iñupiat Community of the Arctic Slope
City of Nuiqsut
North Slope Borough
State of Alaska

Estimated Total Costs Associated with
Developing and Producing this EIS:
$5,281,000

Mission

To sustain the health, diversity, and productivity of the public lands for the future use and enjoyment of present and future generations.

Cover Photo Illustration: Caribou in the Alpine Development on Alaska's North Slope.
Photo by: Wendy Mahan, courtesy of ConocoPhillips.

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Draft Environmental Impact Statement

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Willow Master Development Plan

Appendix B
Public Engagement and Scoping Summary Report

August 2019

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List of Acronyms

BLM	Bureau of Land Management
EIS	Environmental Impact Statement
NEPA	National Environmental Policy Act

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1.0 PUBLIC ENGAGEMENT

Public involvement is an integral part of the National Environmental Policy Act (NEPA) process and is required in the preparation and implementation of agencies' NEPA procedures. The Bureau of Land Management (BLM) published a Notice of Intent to prepare an Environmental Impact Statement (EIS) on August 7, 2018, and held public scoping meetings from August 20, 2018, to September 18, 2018 (Table B.1). Meeting dates and locations were advertised on the BLM website and through local media (print and radio). Flyers on meetings were also sent to local organizations to be posted in public locations.

Table B.1. Scoping Meeting Dates and Locations

Meeting	Date	Location
Public meeting #1	August 20, 2018	Utqiaġvik (Barrow)
Public meeting #2	August 22, 2018	Fairbanks
Public meeting #3	August 23, 2018	Anchorage
Public meeting #4	August 27, 2018	Atqasuk
Public meeting #5	August 29, 2018	Anaktuvuk Pass
Public meeting #6	September 18, 2018	Nuiqsut
Community open house	November 1, 2018	Nuiqsut

The presentation used during public scoping, public and agency input received during the scoping process, and a summary scoping report are available on the BLM website. The Scoping Summary Report is also provided in Section 2.0 of this appendix.

2.0 SCOPING SUMMARY REPORT

See Scoping Summary Report on the following page.

U.S. Department of the Interior
Bureau of Land Management

Willow MDP EIS Scoping Report

1.0 INTRODUCTION

ConocoPhillips Alaska, Inc. is proposing to construct a series of infrastructure components for the purpose of oil and gas development in the Northeast Planning Area of the National Petroleum Reserve in Alaska (NPR-A). Under the Willow Master Development Plan (MDP), proposed infrastructure components could include a central processing facility, infrastructure pad, up to five drill pads with up to 50 wells on each pad, access and infield roads, an airstrip, pipelines, a gravel mine, and a temporary island to support module delivery via sealift barges. The construction and operation of these facilities require authorizations from the U.S. Department of the Interior Bureau of Land Management (BLM). Per National Environmental Policy Act (NEPA) requirements, the BLM must prepare an Environmental Impact Statement (EIS) for the Willow MDP to analyze the potential environmental impacts and mitigation measures for this proposal and make an informed decision. As required under NEPA, a scoping period was initiated to solicit comments from the public and to inform the completion of the EIS. This report summarizes the scoping comments received in terms of the number, type, and common themes or topics raised.

2.0 SCOPING PROCESS

The Willow MDP/EIS scoping period began on August 7, 2018, with the publication of a Notice of Intent (NOI) in the Federal Register. The original scoping period was 30 days; however, it was extended by 14 days due to public requests and officially ended on September 20, 2018. The community of Nuiqsut was given an additional 8 days to comment, for a total of 52 days, because many community members were whaling during much of the scoping period. The scoping period was announced in the Federal Register, local newspaper ads and radio announcements, postcard mailers to the mailing list (including all Post Office boxes in Nuiqsut), a BLM news release, and the BLM website. The public notice materials will be retained in the project files for future reference. Public comments were received via email, mail, and at public meetings.

Between August 20 and September 18, 2018, BLM Alaska hosted six public scoping meetings to summarize the project, solicit public comments, and answer public questions. Meetings were held in Anaktuvuk Pass, Anchorage, Atqasuk, Fairbanks, Nuiqsut, and Utqiaġvik (Barrow). Verbal comments given at scoping meetings were documented in formal transcripts of each individual meeting and published on the Willow MDP/EIS e-Planning webpage.

3.0 COMMENT SUMMARY

A total of 1,430 respondents submitted comments during the scoping period. Of these, the majority of comments were submitted via email or mailed-in letters (98%) and the remainder (2%) submitted verbally at public scoping meetings. Of the comment letters, the majority (95%) were submitted as form letters (i.e., letters containing identical content), while the remainder were either form letters with slight modifications (1%) (e.g., one or two unique sentences added, but otherwise identical to a form letter) or unique comment letters (4%) (i.e., original letters that did not have identical or almost identical wording as another letter). The 1,330 form letter submissions all originated from a total of five unique form master letters, some of which shared overlapping phrases or bullet points.

Nearly all respondents were individuals (99%), with the exception of one tribe, two Native corporations, one business, four organizations, and eight government agencies (Table 1). Individuals who provided their business title or employer information in their letter or testimony but did not state that they were an official representative were counted as individuals as opposed to businesses or organizations.

Table 1. Respondent Group Types

Respondent Group Type	Respondent Title
Businesses	North Star Terminal and Equipment Services
Tribes/Tribal Corporations	Native Village of Nuiqsut*
	Kuukpik Corporation
	Doyon Limited
Organizations	Audubon Alaska
	Combined comment from: Alaska Climate Action Network, Alaska Wilderness League, Center for Biological Diversity, Conservation Lands Foundation, Defenders of Wildlife, Earthjustice, Northern Alaska Environmental Center, and The Wilderness Society
	Resource Development Council
	Alaska Chamber
Government Agencies	Environmental Protection Agency*
	U.S. Fish and Wildlife Service*
	Alaska Department of Natural Resources (DNR) Division of Mining, Land, and Water*
	Alaska DNR Division of Oil and Gas*
	Alaska DNR Office of Project Management and Permitting*
	Alaska Office of History and Archaeology/State Historic Preservation Office*
	Alaska Department of Fish and Game*
	North Slope Borough*

*Cooperating agency

Within each comment letter or verbal transcript, individual comments (i.e., stand-alone comments that relate to a single issue, idea, or conclusion) were identified and grouped into one or more of the following categories listed in Table 2. Comment categories are either defined by individual resources which may be affected by the project, individual elements of the proposed project, or specific phases and aspects of the EIS/NEPA process (Table 2). Categories are intended to describe the main topic or resource that is discussed in the comment, regardless of whether the comment is expressing opposition or support for the project as it relates to that topic. Any comments identified within form letters were categorized only once and counted as a single comment no matter how many form letters with that same comment were submitted.

Table 2. Comment Categories

Resource Topics	Project Element Topics	EIS/NEPA Process Topics
Caribou and General Wildlife Subsistence Safety/Emergency Response Human Health General Socioeconomics Nuiqsut Socioeconomics Air Quality Water Quality Teshekpuk Lake Special Area Domestic Oil Production/Tran-Alaska Pipeline System Climate Change	General Statement of Support Proponent Track Record Project Description Mitigation Minimal Environmental Impacts Integrated Activity Plan (IAP)	EIS Process/Timeline Stakeholder Engagement Cumulative Effects Alternatives Request for Extended Scoping Period

A total of 377 individual comments were identified from the various letters and verbal testimonies and categorized, as shown in Table 3. Half of all comments (50%) fell into the following top five categories: General Socioeconomics, Subsistence, Nuiqsut Socioeconomics, Alternatives, and Proponent Track Record. Additional details concerning the content of comments and their key points are summarized in Table 4.

Table 3. Comments Received

Comment Category	No. Comments Received	% Total Comments
General Socioeconomics	67	17.8%
Subsistence	39	10.3%
Nuiqsut Socioeconomics	29	7.7%
Alternatives	26	6.9%
Proponent Track Record	26	6.9%
General Statement of Support	23	6.1%
EIS Process/Timeline	21	5.6%
Caribou and General Wildlife	20	5.3%
Domestic Oil Production/Trans-Alaska Pipeline System	18	4.8%
Human Health	17	4.5%
Project Description	15	4.0%
Air Quality	12	3.2%
Stakeholder Engagement	11	2.9%
Minimal Environmental Impacts	10	2.7%
Safety/Emergency Response	7	1.9%
Cumulative Effects	6	1.6%
Mitigation	6	1.6%
Teshekpuk Lake Special Area	6	1.6%
Climate Change	5	1.3%
Water Quality	5	1.3%
2013 Integrated Activity Plan	4	1.1%
Request for Extended Scoping Period	4	1.1%
Sum	**377**	**100%**

Table 4. Comment Summary

Comment Category	Summary of Key Points
General Socioeconomics	Commenters requested that the EIS include an analysis of potential benefits to local/state/national economies resulting from construction/operation/indirect jobs, increased tax revenue and royalties, reduced TAPS tariffs, the NPR-A Impact Mitigation Grant Program, project-funded environmental/biological research, project-funded infrastructure (e.g., roads or pipeline spurs), a low-cost natural gas supply for Nuiqsut, and potential indirect environmental benefits resulting from these socioeconomic improvements. Comments stated that the EIS should identify the specific communities (including any that are low income or minority), federally recognized tribes, and corporations that could be impacted socioeconomically as a result of changes in subsistence-based economies and access to traditional use areas and traditional foods.
Subsistence	Commenters requested that the EIS evaluate the potential benefits of new roads for subsistence hunting, and for people who don't have off-road capable vehicles or snowmobiles. Respondents also indicated that the EIS should evaluate potential adverse effects of air/ground traffic, blasting/mining activities, and project infrastructure (including roads, gravel island, haul routes, gravel mine, or pipelines) on caribou migration patterns and other species of wildlife, and the resulting impacts to subsistence hunting, fishing, or whaling, especially for the Nuiqsut community. Nuiqsut community members requested that mitigation should be provided for any adverse impacts to Nuiqsut subsistence hunting. Kuukpik Corporation encouraged any analysis of access road impacts to include a thoughtful and balanced analysis of both potential adverse impacts (on caribou/avoidance effect, air quality, water quality or other resources) as well as potential beneficial impacts to subsistence hunters/access (in terms of the number of trips, areas able to be accessed, areas subject to reduced pressure, etc.). One comment requested that the BLM should not allow the gravel mine to be reclaimed and used as a human-made lake with artificially introduced fish for subsistence use. Respondents requested specific attention be given to important subsistence areas such as Fish Creek, Judy Creek, and Harrison Bay.
Nuiqsut Socioeconomics	Commenters requested that the EIS evaluate potential adverse socioeconomic or environmental justice impacts to the Village of Nuiqsut resulting from: health impacts and cost of medical treatment, subsistence impacts and cost of food subsidies, and increased use of public resources including health clinics and emergency response resources, as well as evaluating whether project-created jobs could specifically benefit the village of Nuiqsut. Some comments also stated that the BLM should re-evaluate NPR-A royalty distributions, and whether or not royalties are being distributed in a fair and equitable manner where the number of royalty shares are commensurate with the severity of impacts felt by the community. The Native Village of Nuiqsut requests that any analysis of potential impacts to tribal communities and resources be performed in accordance with their Project and Land Management Evaluation Rubric as well as Section VIII of the Alaska National Interest Lands Conservation Act.
Proponent Track Record	Commenters expressed confidence in the Project Proponent's (ConocoPhillips Alaska, Inc.) ability to construct and operate a project on the North Slope in an environmentally responsible and safe manner, working cooperatively with stakeholders and in a way that respects and protects the subsistence lifestyle of local communities.
General Statement of Support	Commenters expressed their general support for "responsible oil and gas developments" in the NPR-A, including the proposed Willow Master Development Plan.
EIS Process/Timeline	Most comments within this category encouraged BLM to complete the EIS analysis in a timely and efficient manner, consistent with new executive orders and secretarial guidance and focusing on the issues that matter most to the public. Commenters added that the sooner the project gets approved, the sooner project-related socioeconomic benefits can be realized for local and state economies. In addition, commenters encouraged the use of a science-based approach. Some commenters requested that BLM ask for additional time or page allowances beyond what is allowed in recent executive and secretarial orders to facilitate a more thorough analysis that will be less vulnerable to legal challenges.
Domestic Oil Production/TAPS	Commenters requested that the EIS include an analysis of potential increases in domestic oil production and associated benefits to national energy and economic security, and the long-term viability and integrity of the TAPS.

Comment Category	Summary of Key Points
Caribou and General Wildlife	Commenters requested that the EIS evaluate potential impacts to caribou and wildlife migration patterns, flora and fauna, fish species, aquatic habitats, wildlife habitat, and fragmentation and associated wildlife impacts. These comments also stated that the evaluation should be done in a scientifically sound manner and should reference existing protections for flora and fauna in the NPR-A IAP/EIS. Specifically, some respondents asked that the EIS evaluate potential impacts to: special areas protected under the IAP and which have been set aside for their importance to caribou, including Teshekpuk Lake Special Area and Colville River Special Area; tundra habitats and species from thermokarst development; caribou migration patterns or avoidance effects from module delivery, aboveground/elevated pipelines, ice roads, and winter activities; shorebirds and waterfowl from habitat loss and aircraft flushing; bird species of concern from habitat loss and roads; whales, seals, and other aquatic species from the gravel island in Harrison bay; and fish species from road crossings and gravel mining. Other requested analysis in comments included: impacts of gravel island and vessel traffic on nearshore/aquatic habitats, fish passage, whales and marine mammal movement, polar bear movement, and bird migration. Kuukpik Corporation requested that at least one alternative be developed and evaluated in the EIS that is specifically aimed at minimizing impacts to caribou, such as modifying some of the infield road alignments to run parallel, instead of perpendicular, to caribou migration patterns, or an elevated loop system to reduce caribou deflection.
Project Description	Commenters requested that the EIS include more detail and explanation for the following project components: timing, design, and location of the proposed developments; reclamation activities; miles of ice roads per year; the difference between “other proposed infrastructure” and roads and pipelines; details concerning the timing and duration of blasting activities; plans for reclamation or continued use of the gravel mine site following project construction; wastewater discharge details; anticipated solid and hazardous waste generation and management methods; injection wells; and dredging and sediment disposal details.
Alternatives	Commenters suggested alternative elements of the proposed action should include: eliminating gravel island/ocean overland transfer in favor of ice road/overland transfer; removal of gravel island in lieu of leaving it in place; a different mine site location to minimize gravel hauling distances; eliminating the new Willow airstrip/runway and using the existing one at Alpine; using the existing central processing facility in Prudhoe Bay instead of building a new one; alternative drill site and road locations or road alignments (east-west instead of north-south); innovative pipeline designs, such as an elevated loop system; widening Willow Road for use as an airstrip in lieu of constructing an entirely new standalone airstrip; road routes with or without connections to Greater Mooses Tooth 2; a roadless alternative (aircraft only); making Willow or Nuiqsut a hub for future NPR-A developments as opposed to Alpine; eliminating or minimizing the number of roads or other proposed facilities within Teshekpuk Lake Special Area and Colville River Special Areas (specifically, eliminating the approximately 7-mile north-south drill site access road through Teshekpuk Lake Special Area or eliminating drill sites BT2 and BT4 and the roads to them); or any other alternative design that reduces the footprint of the project and reduces the amount of new infrastructure being proposed. In addition, the U.S. Environmental Protection Agency commented if unavoidable impacts to jurisdictional wetland and waters are proposed, an alternatives analysis to satisfy the Section 404(b)(1) guidelines of the Clean Water Act will be required to support a finding that the proposed discharge represents the “least environmentally damaging practicable alternative.”
Human Health	Commenters requested that the EIS consider potential adverse impacts of the project on human health as a result of air pollution, water pollution, stress, limited access to medical resources, changes in socioeconomic status, or changes in traditional way of life and diet. Specific concerns expressed by respondents include asthma and other respiratory and cardiovascular diseases, cancer, genetic mutations and endocrine disruption, bioaccumulation of toxins in animals and food, general exposure to toxins in air and drinking water, reduced access to traditional food sources or inadequate food supply. Some commenters indicated that a health risk assessment or health impact assessment may be warranted and that the BLM should consider partnering with local, state, tribal, and federal health officials to determine an appropriate path forward and to identify data needs. The Village of Nuiqsut requested that a qualified third party with no conflicts of interest be responsible for preparing the health impact assessment.

Comment Category	Summary of Key Points
Minimal Environmental Impacts	Commenters generally indicated that they felt the project would result in minimal environmental impacts if the following industry standards or project elements are implemented: implementation of North Slope best management practices, use of existing road and pipeline infrastructure in the Alpine/Kuparuk areas and Colville River/Kuparuk River Units to minimize project footprint, maintaining standards for safety and emergency response, maintaining rigorous industry standards for environmental and subsistence protections on North Slope, and use of modern technology or design refinements to minimize the project footprint.
Air Quality	Commenters requested that the EIS evaluate potential air quality impacts from project emissions including: fine particulate matter, diesel exhaust, anthrax released from thawing permafrost, benzene, hydrogen sulfide, hazardous air pollutants, ozone, smoke, and volatile organic compounds. Respondents stated that any potential sources of emissions should be described along with their associated air pollutants, such as heavy machinery, flaring of gas, activities or equipment that can cause fugitive dust or leaks, and marine vessels. Some comments also asked that air quality modelling be performed to support the analysis presented in the EIS, and potential mitigation and control measures be identified.
Stakeholder Engagement	Many commenters expressed confidence in the Project Proponent's track record for engaging and cooperating with stakeholders on the North Slope. Conversely, several commenters, particularly people from, or advocating for, tribal communities such as the Village of Nuiqsut, requested an increased effort from BLM to engage with the tribe and address all of their comments and concerns in the development of the EIS. These commenters also requested that BLM better define and clarify the tribe's role in the NEPA process and recommended incorporating traditional cultural knowledge into the EIS analysis where appropriate. The Native Village of Nuiqsut expressed concern over their ability to provide meaningful input and engagement throughout the NEPA process for Willow given the number of regional planning projects currently underway and capacity challenges for the tribe.
Safety/Emergency Response	Commenters requested that the EIS evaluate potential beneficial or adverse impacts to emergency response as a result of new roads and airstrips, or the potential for public travel along project access roads leading to an increased need for emergency response (e.g., towing assistance). Commenters also requested that the EIS discuss spill and emergency response procedures and capabilities given the remote nature of the site, potential seismic risks, spill and leak detection methods, containment and cleanup operations, hazardous materials management and storage, and any toxic hazards.
Climate Change	Commenters requested that the EIS consider long-term and cumulative effects of climate change, including potential changes in weather, vegetation, seismic activity, or sea-level rise/flooding. In addition, commenters requested that the EIS discuss the relationship between thermokarst and climate change and how this might have a cumulative effect on environmental resources when combined with project-related impacts.
Teshekpuk Lake Special Area	Commenters requested that the EIS evaluate potential impacts to wetlands and caribou and other wildlife species and habitats within the Teshekpuk Lake Special Area, and any resulting subsistence impacts to North Slope communities. Respondents stated that the EIS should also describe protections for the Teshekpuk Lake Special Area and how the project complies with applicable use or development restrictions.
Water Quality	Commenters requested that the EIS characterize existing aquatic habitats and water resources in the area and evaluate potential water quality impacts including: introduction of water pollutants, compliance with water quality standards, downstream impacts, water use during construction or operation, groundwater injections, erosion and sedimentation, wastewater discharges, mercury and anthrax released from thawing permafrost, and xylene and benzene.
IAP	Commenters stated that the project conforms to the BLM's 2013 IAP, with no appreciable changes, which further supports and justifies statements of minimal environmental impacts and commenter requests for a timely and efficient EIS process.
Mitigation	Commenters requested that the EIS identify all activities needing mitigation and the types of mitigation activities proposed during construction, operation, or decommissioning of the project. Respondents noted that the EIS should identify the responsible parties for implementing mitigation, monitoring requirements, and where the public can find mitigation effectiveness and monitoring results as they become available. Commenters encouraged the use of the mitigation hierarchy (avoidance, minimization, and compensatory offsets) to ensure that unavoidable impacts are effectively and meaningfully offset with appropriate mitigation.

Comment Category	Summary of Key Points
Request for Extended Scoping Period	Commenters requested additional time to submit scoping comments, based on the complexity of the project, severity of potential impacts, timing of scoping overlapping with timing of subsistence activities, and/or multiple other concurrent or connected development actions currently being planned and reviewed within the region.
Cumulative Effects	Commenters requested that the Cumulative Effects analysis consider future/concurrent/nearby leases and proposed explorations such as Nanushuk, Smith Bay, Alpine CD-5, Special Alaska Lease Sale Areas, and Greater Mooses Tooth 1 and 2, or other projects planned for development on Nuiqsut's traditional subsistence lands which have yet to be constructed. Cumulative effects to the community of Nuiqsut, relating to noise, traffic, thermokarsting, dust, water quality, and human health were specifically mentioned as a concern by some respondents.

Notes: BLM (Bureau of Land Management); EIS (environmental impact statement); IAP (Integrated Activity Plan); NEPA (National Environmental Policy Act); NPR-A (National Petroleum Reserve in Alaska); TAPS (Trans-Alaska Pipeline System).

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Willow Master Development Plan

Appendix C
Regulatory Authorities and Framework

August 2019

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List of Tables

List of Acronyms

ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
BLM	Bureau of Land Management
EIS	Environmental Impact Statement
ESA	Endangered Species Act
NEPA	National Environmental Policy Act
NMFS	National Oceanic and Atmospheric Administration National Marine Fisheries Service
NVN	Native Village of Nuiqsut
Project	Willow Master Development Plan Project
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture

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1.0 SUMMARY OF PERMITS, APPROVALS, AND CONSULTATIONS REQUIRED

Oil and gas development on Alaska's North Slope requires dozens of permits, approvals, and other reviews and consultations. Table C.1.1 provides a full list of anticipated permits, approvals, and consultations as well as a list of applicable federal laws and executive orders.

Table C.1.1. Federal, State, and Local Applicable Laws, Executive Orders, Permits, Approvals, and Consultations

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Federal laws and executive orders common to multiple federal agencies	National Environmental Policy Act (NEPA) of 1969 (42 USC 4321)	NEPA requires all federal agencies to prepare a detailed statement of the environmental effects of proposed major federal actions with potential to significantly affect the quality of the human environment.	Environmental impact statement (EIS)
Federal laws and executive orders common to multiple federal agencies	National Historic Preservation Act (NHPA) of 1966 (16 USC 470)	Before issuing a federal authorization, federal agencies must consider the effect of the undertaking on historic properties (resources listed or determined eligible for the National Register of Historic Places) and must consult with State Historic Preservation Office (SHPO), Indian Tribes,[a] and other parties. Federal agencies must provide the Advisory Council on Historic Preservation with a reasonable opportunity to comment on the Willow Master Development Plan (Project).	NHPA Section 106 Consultation
Federal laws and executive orders common to multiple federal agencies	Alaska Native Claims Settlement Act (ANCSA) of 1971 (43 USC 1601 et seq.)	ANCSA required the conveyance of lands to Alaska Native regional and village corporations providing surface and subsurface rights. The Arctic Slope Regional Corporation and Kuukpik Corporation own subsurface and surface lands, respectively, in the Project area.	Coordination with ANCSA landowners
Federal laws and executive orders common to multiple federal agencies	American Indian Religious Freedom Act of 1978 (42 USC 1996)	Federal agencies must consider Native American religious concerns when a federal management decision has the potential to restrict access or ceremonial use of, or affect the physical integrity of sacred sites (on both federal and nonfederal lands affected by the federal action).	Consideration of impacts to activities protected under this act
Federal laws and executive orders common to multiple federal agencies	Alaska National Interest Lands Conservation Act (ANILCA) of 1980	For any federal determination to "withdraw, reserve, lease, or otherwise permit the use, occupancy or disposition of public lands," an evaluation of subsistence uses and needs must be completed.	ANILCA Section 810 Analysis
Federal laws and executive orders common to multiple federal agencies	Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (25 USC 3001 et seq.)	NAGPRA establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands and establishes ownership of cultural items excavated or discovered.	Evaluation of potential impacts to resources protected under NAGPRA
Federal laws and executive orders common to multiple federal agencies	Freedom of Information Act (FOIA) of 1966 (5 USC 552)	The FOIA allows for the full or partial disclosure of previously unreleased information and documents controlled by the U.S. government.	Public disclosure of project records
Federal laws and executive orders common to multiple federal agencies	EO 11514 (1970) – Protection and Enhancement of Environmental Quality	EO 11514 directs the U.S. government to provide leadership in protecting and enhancing the quality of the environment. Federal agencies are to initiate measures to direct their policies, plans, and programs to meet national environmental goals.	Review and evaluation of the Draft and Final EIS by the U.S. Environmental Protection Agency (EPA) for compliance with Council on Environmental Quality guidelines

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Federal laws and executive orders common to multiple federal agencies	EO 11988 (1977) – Floodplain Management	EO 11988 requires federal agencies to reduce the risk of flood loss; to minimize the impact of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibilities.	Establishment of procedures ensuring that the potential effects of flood hazards and floodplain management are considered for actions undertaken in a floodplain
Federal laws and executive orders common to multiple federal agencies	EO 11990 (1977) – Protection of Wetlands	EO 11990 requires federal agencies to take action to minimize the destruction, loss, or degradation of wetlands and to take action to preserve and enhance wetlands in carrying out their responsibilities.	Avoidance of short- and long-term adverse impacts to wetlands whenever a practicable alternative exists
Federal laws and executive orders common to multiple federal agencies	EO 12898 (1994) – Environmental Justice	EO 12898 requires that federal agencies identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations to the greatest extent practicable and permitted by law.	Assessment of environmental justice in the EIS
Federal laws and executive orders common to multiple federal agencies	Executive Memorandum – Government-to-Government Relationship with Native American Tribal Governments (1994)	Federal agencies must consult with tribal governments prior to taking actions that would affect federally recognized tribal governments or tribal trust resources. Federal agencies must act in a knowledgeable and sensitive manner respectful of tribal sovereignty.	Government-to-government relations with Native American tribal governments
Federal laws and executive orders common to multiple federal agencies	EO 12962 (1995) – Recreational Fisheries	EO 12962 requires that federal agencies improve the quantity, function, sustainable productivity, and distribution of aquatic resources for increased recreational fishing opportunities.	Evaluation of potential effects to aquatic systems and recreational fisheries
Federal laws and executive orders common to multiple federal agencies	EO 13045 (1997) – Protection of Children from Environmental Health and Safety Risks	EO 13045 requires federal agencies to assess environmental health and safety risks that may disproportionately affect children and to ensure their policies, programs, activities, and standards address the disproportionate risks to children.	Evaluation of the potential impacts to human health, including children
Federal laws and executive orders common to multiple federal agencies	EO 13112 (1999) – Invasive Species	EO 13112 aims to prevent the introduction of invasive species; to control invasive species already introduced; and to minimize the economic, ecological, and human health impacts of invasive species.	Prevention of the introduction of invasive species, control of introduced species, and restoration of native species
Federal laws and executive orders common to multiple federal agencies	EO 13175 (2000) – Consultation and Coordination with Indian Tribal Government	EO 13175 requires federal departments and agencies to consult with Indian tribal governments when considering polices that would substantially impact tribal communities.	Consultation and coordination with Indian tribal governments
Federal laws and executive orders common to multiple federal agencies	EO 13186 (2001) – Responsibilities of Federal Agencies to Protect Migratory Birds	EO 13186 helps federal agencies to comply with the Migratory Bird Treaty Act and to reduce their liability for the unintentional take of migratory birds.	Avoidance or minimization of the impacts to migratory birds and protection of birds and their habitats

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Federal laws and executive orders common to multiple federal agencies	EO 13783 (2017) – Promoting Energy Independence and Economic Growth	EO 13783 requires federal agencies to review existing regulations that potentially burden the development or use of domestically produced energy resources and appropriately suspend, revise, or rescind those that unduly burden the development of domestic energy resources beyond the degree necessary to protect the public interest or otherwise comply with the law.	EO 13783 revokes EO 13653 – Preparing the United States for the Impacts of Climate Change – and withdraws the Council on Environmental Quality's Memorandum: Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews (81 FR 51866)
U.S. Department of Interior	Naval Petroleum Reserves Production Act (NPRPA) of 1976	Conduct oil and gas leasing in the NPR-A and implement regulations as deemed necessary for the protection of important surface resources and uses.	Review of Application for Permit to Drill in NPR-A Implementation of protections for surface resources
U.S. Army Corps of Engineers (USACE)	Clean Water Act (CWA) of 1972, amended 1977 (33 USC 1344)	The CWA regulates the discharge of dredged or fill material into Waters of the United States (WOUS), including wetlands.	Department of Army (DA)/CWA Section 404 Permit
USACE	Rivers and Harbors Act (RHA) of 1899 (33 USC 403)	The RHA regulates work and structures in, over, or under navigable WOUS, as well as work and structures that affect the course, location, condition, or capacity of WOUS.	DA/RHA Section 10 Permit
EPA	CWA of 1972, amended 1977 (33 USC 1251 et seq.) (40 CFR 110 and 112)	EPA has the following authority under the CWA: Section 311*:* EPA requires owners and operators to prepare and implement Spill Prevention, Control, and Countermeasures (SPCC) Plans for facilities storing more than 1,320 gallons in aggregate in aboveground tanks with a capacity of 55 gallons or more. Section 402: EPA oversees draft Alaska Pollutant Discharge Elimination System (APDES) permits and can object to proposed permit decisions. Section 404: EPA reviews and comments on permit applications for compliance with Section 404(b)(1) guidelines and other statutes and authorities within their jurisdiction.	Oversight of SPCC Rule requirements Review of APDES permits Review of DA (Section 404) permits

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
EPA	Clean Air Act (CAA) of 1967, amended 1990 (42 USC 7401 et seq.)	Under Section 309 of the CAA, EPA reviews and evaluates environmental effects and the adequacy of Draft and Final EIS documents. EPA has program oversight responsibilities of the Alaska Department of Environmental Conservation's (ADEC) implementation of the CAA program in Alaska, which gives ADEC authority to issue air quality control permits.	Section 309 evaluation
EPA	Oil Pollution Act (OPA) of 1990 (40 CFR 112.20)	Section 4202 of the OPA amended CWA Section 311(j) by requiring owners and operators of tank vessels, offshore facilities, and certain onshore facilities to prepare and submit Facility Response Plans.	Review of Facility Response Plans
EPA	Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 6901 et seq.)	The RCRA establishes criteria governing the management of hazardous waste. Any hazardous waste generated at a facility is subject to the hazardous waste regulations administered by EPA.	Permits for the transportation and storage of hazardous waste material
EPA	Toxic Substances Control Act (TSCA) of 1976 (15 USC 2601 et seq.)	Under the TSCA, the EPA is authorized to require reporting, recordkeeping, testing requirements, and restrictions related to chemical substances and mixtures.	Reporting requirements
EPA	Underground Injection Control (UIC) Program (40 CFR 144)	The UIC Program regulates construction of Class I UIC wells for nonhazardous liquids and municipal wastewater.	Class I UIC permit
EPA	Standards of Performance for New Stationary Sources (40 CFR 60) National Emission Standards for Hazardous Air Pollutants for Source Categories (40 CFR 63)	Standards of Performance for New Stationary Sources establish federal standards of performance for new, modified, and reconstructed stationary sources within certain source categories. National Emission Standards for Hazardous Air Pollutants for Source Categories sets technology-based standards to regulate hazardous air pollutants from certain sources within specific source categories.	Compliance with certain equipment specifications and emission limits Requirements for monitoring, recordkeeping, reporting, operation, and maintenance
EPA	Noise Control Act (42 USC 4901)	The Noise Control Act of 1972 requires federal agencies to comply with all federal, state, and local noise control laws and regulations. In 1991, the federal government transferred primary responsibility for noise issues to state and local governments. There are no local noise thresholds at the state or local level for the Project area.	Investigate and study noise and its effects Disseminate information to the public regarding noise pollution and its adverse health effects
U.S. Coast Guard (USCG)	Title 33, Navigation and Navigable Waters (33 CFR 114 and 115) RHA and the General Bridge Act (33 USC 401, 491, 525)	USCG approves bridge permits to ensure navigability.	Bridge permits

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
USCG	Title 33, Navigation and Navigable Waters, Subchapter P, Ports and Waterways Safety (33 CFR 160–169)	As authorized by Title 33, Subchapter P, the USCG approves bridge design in navigable waters, and the USCG and Department of Homeland Security approve safety features in ports and waterways.	Application for cargo transfer operations Port operations manual approval Facility Response Plans Private aids to navigation authorization Tug and barge vessel inspections Notice to mariners
U.S. Department of Transportation (USDOT), Pipeline and Hazardous Materials Safety Administration (PHMSA)	Pipeline Safety (49 CFR 190–199); Pipeline Inspection, Protection, Enforcement, and Safety Act of 2006 (Public Law 109-468) Pipeline Safety Statute (49 USC 60101–60301)	Pipeline transportation and pipeline facilities must meet the minimum standards for safety, inspection, protection, and enforcement as regulated by the USDOT and PHMSA. A special permit is required for any exceptions to the PHMSA regulations.	PHMSA approvals Review of Facility Response Plans
USDOT, PHMSA	Hazardous Materials Transportation Act of 1975 (49 USC 5101–5127)	Hazardous materials must be transported according to USDOT regulations. PHMSA has regulatory and civil enforcement authority over the transportation of explosive materials in commerce.	Hazardous materials transportation requirements and registration License to transport explosives
U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS)	Bald and Golden Eagle Protection Act of 1940 (16 USC 668 et seq.)	USFWS issues permits for the relocation of bald and golden eagle nests that interfere with resource development or recovery operations.	Permits to take, haze, relocate, or destroy birds or their nests for public safety purposes
USFWS and NMFS	Marine Mammal Protection Act (MMPA) of 1972 (16 USC 1361 et seq.)	The MMPA prohibits the harassment, hunting, capture, or killing of marine mammals, or the attempt to harass, hunt, capture, or kill marine mammals, and requires Incidental Take Authorizations (ITAs) for any exemptions. The USFWS and NMFS have joint regulatory authority to implement the MMPA.	ITAs (as necessary): Letters of authorization or incidental harassment authorizations
USFWS and NMFS	Migratory Bird Treaty Act (MBTA) of 1918 (16 USC 703–709)	The MBTA prohibits the pursuit, hunt, take, capture, kill, or sale of migratory birds. USFWS is authorized to implement provisions of the MBTA and may issue waivers or permits.	USFWS consultation
USFWS and NMFS	Endangered Species Act (ESA) of 1973 (16 USC 1531)	The USFWS and NMFS have joint regulatory authority to manage species protected under the ESA. The USFWS and NMFS consult on the effects to threatened or endangered species and their designated critical habitat, as well as issue ITAs. Species include terrestrial mammals, plants, birds, and marine mammals.	ESA consultation, USACE issuance of biological assessments, USFWS/NMFS issuance of concurrence or biological opinion

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
USFWS and NMFS	Fish and Wildlife Coordination Act (FWCA) of 1980	The FWCA authorizes the USFWS to assess the potential impacts of water resource development projects on fish and wildlife resources.	Consultation and development of mitigation to offset impacts
USFWS and NMFS	Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976 (16 USC 1361 et seq.)	NMFS provides consultation on the effects to essential fish habitat (EFH), as authorized by the MSA. EFH includes habitats necessary to a species for spawning, breeding, feeding, or growth to maturity.	EFH consultation
U.S. Department of Justice – Bureau of Alcohol, Tobacco, Firearms, and Explosives	Importation, Manufacture, Distribution, and Storage of Explosive Materials (18 USC 1102, Chapter 40) Commerce in Explosives (27 CFR 555)	Bureau of Alcohol, Tobacco, Firearms, and Explosives requires that applicants obtain a permit before they purchase, store, and use explosives for blasting activities.	Permit and license for use of explosives
Federal Communications Commission (FCC)	Communications Act of 1934 (47 USC 151 et seq.)	The FCC regulates interstate and international communications by radio, television, wire, satellite, and cable, including radio licensing.	Radio license
Alaska Department of Conservation	CAA of 1967, amended 1990 (42 USC 7401 et seq.) Air Quality Control (18 AAC 50 et seq.)	Primary responsibility is to control and mitigate air pollution in Alaska, as well as to issue air quality control permits for construction and operations of stationary sources.	Air quality control minor permit
ADEC	CWA of 1972, amended 1977 (33 USC 1251 et seq.)	Section 401 requires (for the USACE 404 permit) ADEC to certify that discharges into WOUS will comply with the CWA, the Alaska Water Quality Standards (18 AAC 70), and other applicable state laws.	Section 401 Water Quality Certification
ADEC	CWA of 1972, amended 1977 (33 USC 1251 et seq.) Wastewater Disposal (18 AAC 72) APDES (18 AAC 83) Water Quality Standards (18 AAC 70) Drinking Water Standards (18 AAC 80)	ADEC has the following authority under the CWA: Provides approval for domestic wastewater collection, treatment, and disposal plans for domestic wastewater Requires a permit for the disposal of domestic and nondomestic wastewater Fully administers EPA's National Pollutant Discharge Elimination System program through the APDES Provides approval for treatment and disposal plans for industrial wastewater Establishes and enforces water quality standards and limits for surface waterbodies Establishes standards for design, construction, and operation of public water systems, including contaminant monitoring requirements	APDES permits (e.g., North Slope Oil and Gas General Permit) Review of Stormwater Pollution Prevention Plans Reviews of treatment systems for drinking water and wastewater Domestic wastewater disposal permit Nondomestic wastewater disposal permit
ADEC	Solid Waste Management (18 AAC 60; AS 46.03.100)	Reviews and approves Solid Waste Processing and Temporary Storage Facilities Plans for handling and temporary storage of solid waste and landfills.	Integrated waste management permit/plan approval

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
ADEC	Food Permit and Registration Requirements (18 AAC 31.020)	Issues permits to operate a food establishment.	Food establishment permit
ADEC	Drinking Water System Classification and Plan Approval (18 AAC 80)	May issue approval of public drinking water plans.	Potable water-well logs Approval to construct and operate a public water supply system Public water system identification number
ADEC	Safe Drinking Water Act (Part C) Wastewater Treatment and Disposal (18 AAC 72)	Grind and inject facilities require approval. EPA regulates UIC wells.	Approval for grind and inject facilities Wastewater disposal permit
ADEC	Oil and Hazardous Substances Pollution Control Regulations (18 AAC 75; AS 46.04.040, 050)	Requires an Oil Discharge Prevention and Contingency Plan and Proof of Financial Responsibility for the following: Vessels and petroleum product barges that operate on state waters Oil and gas exploration or development projects Oil terminal/storage facility capable of storing 5,000 barrels or more of crude oil or 10,000 barrels or more of refined petroleum products Aboveground or belowground storage capacity greater than 10,000 barrels (420,000 gallons) of refined petroleum products	Oil Discharge Prevention and Contingency Plan
Alaska Department of Fish and Game (ADF&G)	FWCA (16 USC 2901; 16 USC 661 et seq.)	Provides comments and recommendations to federal agencies, pursuant to the FWCA. ADF&G also consults with the USFWS to conserve and improve wildlife resources.	Wildlife consultation Fish habitat permits
ADF&G	Anadromous Fish Act (AS 16.05.871)	Provides authorization for activities that could use, divert, obstruct, pollute, or change the natural flow or bed of rivers, lakes, and streams used by anadromous fish.	Fish habitat permits
ADF&G	Fishway Act (AS 16.05.841)	Provides authorization for activities within or across a stream used by fish, if such activities have been determined to be possible impediments to the efficient passage of resident anadromous fish.	Determination of sufficient fish passage
ADF&G	License, Permit, and Tag Fees; Surcharge; Miscellaneous Permits to Take Fish and Game (AS 16.05.340)	May issue a permit to collect fish and game, subject to limitations and provisions as appropriate, for a scientific, propagative, or educational purpose.	Permit to collect fish and game
ADF&G	Permit for Scientific, Educational, Propagative, or Public Safety Purposes (5 AAC 92.033)	May issue a permit for the taking, possessing, importing, or exporting of game for scientific, propagative, or public safety purposes.	Fish collection permits Hazing of terrestrial mammals Lethal take (e.g., foxes and other carnivores)

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Alaska Department of Natural Resources (ADNR)	Alaska Historic Preservation Act (AS 41.35.010–240) NHPA (54 USC 300101 et seq.; 36 CFR 800.106–110) Archaeological Resources Protection Act of 1979 (16 USC 470)	Section 106 of the NHPA requires consultation with SHPO and, when there are adverse effects to cultural resources listed on or eligible for inclusion in the National Register of Historic Places, with the Advisory Council on Historic Preservation. ADNR's Office of History and Archaeology issues a field archaeology permit for archaeological fieldwork on state lands; USACE would consult with the Office of History and Archaeology. SHPO issues a Cultural Resources Concurrence for projects that may affect historic or archaeological sites.	Section 106 of the NHPA, Memorandum of Agreement, or Programmatic Agreement Archaeology collection permit Field archaeology permit
ADNR	Oil and Gas Leasing, Unit Plan of Development (11 AAC 83.343) Oil and Gas Leasing, Unit Plan of Operations (11 AAC 83.346)	Unit plans of development and operations are required for approval of activities on state oil and gas leases.	Unit Plan of Development Unit Plan of Operations
ADNR	Sale of Timber and Materials (AS 38.05.110) Permits (AS 38.05.850) Mining Sites Reclamation Plan (AS 27.19)	Issues Material Sales Contracts for mining on and purchasing gravel from state lands, as well as issues right-of-way (ROW) and land use permits for the use of state land or waters and for ice road construction on state land. ADNR also approves Mining Reclamation Plans on state, federal, municipal, and private land and water.	Material Sales Contract Mining license Approval of Reclamation Plan Land use permits and leases Approval of bonding and financial assurance
ADNR	Grant of Right-of-Way Lease (AS 38.35.020)	Issues pipeline ROW leases for new pipeline and pipeline-related construction and operation across state lands.	Issuance of pipeline ROW
ADNR	Water Use Act (AS 46.15)	Issues a Temporary Water Use Permit for water use during construction and operation, as well as water rights permits for appropriating significant amounts of water beyond temporary uses.	Issuance of Temporary Water Use Permit Water permit/certificate to appropriate water
ADNR	Uses Requiring a Permit (11 AAC 96.010)	Permits are required for temporary use of state lands for ice infrastructure, temporary winter off-road travel, and temporary summer off-road travel.	Temporary land use permits
Alaska Oil and Gas Conservation Commission (AOGCC)	Permit to Drill (20 AAC 25.005)	Oversees permitting approval for each well to be drilled or re-drilled.	Permit to drill
AOGCC	Enhanced Recovery Operations (20 AAC 25.402)	Oversees approvals to inject fluid into a well for the purpose of enhanced oil recovery.	Class I UIC enhanced oil recovery well area injection order
AOGCC	Bonding (20 AAC 25.025)	Oversees bonding requirements (bond remains active until wells are plugged and abandoned and well sites are restored).	Establishment of a single-well bond or a statewide bond with AOGCC for each operating company (as regulated under 20 ACC 25.025) to drill, produce, and maintain oil, gas, and geothermal wells

Applicability or Entity	Legal Authority	Agency Responsibility	Requirement
Alaska Department of Public Safety, Division of Fire and Life Safety	General Function of the Department of Public Safety with Respect to Fire Protection (AS 18.70.010) Alaska Fire and Life Safety Regulations (13 AAC 50–55)	Statewide jurisdiction for fire code enforcement and plan review authority, except in communities that have received deferrals (the Municipality of Anchorage, Fairbanks, etc.).	Life and Fire Safety Plan checks Plan review certificate of approval for each building Fire marshal permits
Alaska Department of Public Safety, Division of Fire and Life Safety	2009 International Fire Code (IFC)	All fuel systems being developed to support port and airport operations during pipeline construction must be reviewed and found to conform to the 2009 IFC requirements. If explosive blasting is used, the storage magazine, type, location, and any barricades must meet IFC requirements.	2009 IFC requirements
Alaska Department of Transportation and Public Facilities (DOT&PF)	Permits for Oversize or Overweight Vehicles (17 AAC 25.320)	Issues permits for oversize or overweight vehicles.	Oversize or overweight vehicle permits
DOT&PF	Transportation of Hazardous Materials, Hazardous Substances, or Hazardous Waste (17 AAC 25.200)	Regulates the transportation of hazardous materials, hazardous substances, or hazardous waste by vehicles.	Compliance with the transportation of hazardous materials, hazardous substances, or hazardous waste regulations
Alaska Division of Labor Standards and Safety	Safety (AS 18.60; 8 AAC 61)	The Alaska Division of Labor Standards and Safety ensures that project-related activities meet standards and regulations for occupational health and safety.	Certificates of inspection for fired and unfired pressure vessels Occupational safety and health (inspections and certificates) Employer identification number
Alaska Department of Health and Social Services	Alaska Best Management Practices Alaska Health Impact Assessment Program	Uses existing public health surveillance data, medical literature reviews, and field studies to evaluate the potential human health effects of new policies, programs, or development projects in Alaska.	Participation in Human Health Baseline for project
Alaska Department of Military and Veterans' Affairs	Emergency Planning Districts and Committees (AS 26.23.073) Plan Review (AS 26.23.077)	The Alaska Department of Military and Veterans' Affairs oversees planning and reporting requirements for facilities that handle, store, and manufacture hazardous materials.	Hazardous chemical inventories
Alaska Department of Military and Veterans' Affairs	Hazardous chemical inventories	The State Emergency Response Commission enforces reporting and planning requirements for facilities handling, storing, and manufacturing hazardous materials.	Reporting of hazardous chemicals, materials, and wastes handled
North Slope Borough (NSB)	Rezoning (NSB Code 19.60.060)	Code 19.60.060 regulates the process to zone specific areas for resource development and to conduct activities described in the Master Plan within NSB.	Zoning Map Amendment
NSB	Administrator Approvals (NSB Code 19.50.010)	Code 19.50.010 regulates the approval process for development projects in the NSB.	Industrial development and use permit
NSB	Administrator Approval Criteria (NSB Codes 19.50.030); Planning and Zoning Commission Approval Criteria (NSB Code 19.60.040)	Administrator and Planning and Zoning Commission approvals require confirmation that project areas do not have identified Traditional Land Use Inventory (TLUI) sites or buffer zones for identified TLUI sites.	Certificate of Iñupiat history, language, and culture/TLUI clearance (Form 500)

Notes: ADEC (Alaska Department of Environmental Conservation); ADF&G (Alaska Department of Fish and Game); ADNR (Alaska Department of Natural Resources); ANCSA (Alaska Native Claims Settlement Act); AOGCC (Alaska Oil and Gas Conservation Commission); APDES (Alaska Pollutant Discharge Elimination System); CAA (Clean Air Act); CWA (Clean Water Act); DA (Department of Army); DOT&PF (Alaska Department of Transportation and Public Facilities); EFH (Essential Fish Habitat); EIS (environmental impact statement); EPA (U.S. Environmental Protection Agency); ESA (Endangered Species Act); FCC (Federal Communications Commission); FOIA (Freedom of Information Act); FWCA (Fish and Wildlife Coordination Act); IFC (International Fire Code); ITA (Incidental Take Authorization); MBTA (Migratory Bird Treaty Act); MMPA (Marine Mammal Protection Act); MSA (Magnuson-Stevens Fishery Conservation and Management Act); NAGPRA (Native American Graves Protection and Repatriation Act); NEPA (National Environmental Policy Act); NHPA (National Historic Preservation Act); NMFS (National Oceanic and Atmospheric Administration National Marine Fisheries Service); NSB (North Slope Borough); OPA (Oil Pollution Act); PHMSA (Pipeline and Hazardous Materials Safety Administration); Project (Willow Master Development Plan); RCRA (Resource Conservation and Recovery Act); RHA (Rivers and Harbors Act); ROW (right-of-way); SHPO (State Historic Preservation Office); SPCC (Spill Prevention, Control, and Countermeasures); TLUI (Traditional Land Use Inventory); TSCA (Toxic Substances Control Act); UIC (Underground Injection Control); USACE (U.S. Army Corps of Engineers); USCG (U.S. Coast Guard); USDOT (U.S. Department of Transportation); USFWS (U.S. Fish and Wildlife Service); WOUS (Waters of the U.S.)

[a] Indian tribes as defined by the National Historic Preservation Act and EO 13175 are "an Indian tribe, band, nation, or other organized group or community, including a Native village, regional corporation or village corporation, as those terms are defined in Section 3 of the Alaska Native Claims Settlement Act (43 USC 1602), which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians" (16 USC 470w).

[b] The relationship between federally recognized tribal entities and the U.S. government. This relationship is similar to those employed with other sovereign nations, and mandates consultations with tribes be conducted at an executive or agency-executive level (per EO 13175)

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Willow Master Development Plan

Appendix D
Alternatives Development

August 2019

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List of Acronyms

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ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AOGCC	Alaska Oil and Gas Conservation Commission
APDES	Alaska Pollutant Discharge Elimination System
API	American Petroleum Institute
ASDP	Alpine Satellite Development Plan
BLM	Bureau of Land Management
BMP	best management practice
BT1	Bear Tooth drill site 1
BT2	Bear Tooth drill site 2
BT3	Bear Tooth drill site 3
BT4	Bear Tooth drill site 4
BT5	Bear Tooth drill site 5
BT	Bear Tooth
CD1	Colville Delta drill site 2
CEQ	Council on Environmental Quality
CPAI	ConocoPhillips Alaska, Inc.
CPF2	Kuparuk Central Processing Facility 2
CRSA	Colville River Special Area
cy	cubic yards
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FECP	Facility Erosion Control Plan
FLIR	forward-looking-infrared
GMT-1	Greater Mooses Tooth 1
GMT-2	Greater Mooses Tooth 2
GMT	Greater Mooses Tooth
GW1	Greater Willow 1
GW2	Greater Willow 2
HDD	horizontal directional drilling
HSM	horizontal support member
IAP	Integrated Activity Plan
Kuparuk	Kuparuk River Unit
LEDPA	least environmentally damaging practicable alternative
MDP	Master Development Plan
MG	million gallons
MTI	module transfer island
MLLW	mean lower low water
NEPA	National Environmental Policy Act
NPR-A	National Petroleum Reserve-Alaska
NPRPA	Naval Petroleum Reserves Production Act
NSB	North Slope Borough
NSSRT	North Slope Spill Response Team
OHW	ordinary high water
ODPCP	Oil Discharge Prevention and Contingency Plan
Project	Willow Master Development Plan Project
Q1	first quarter

Q2	second quarter
Q4	fourth quarter
ROD	Record of Decision
SPCC	Spill Prevention Control and Countermeasures
SPMT	self-propelled module transporter
STP	seawater treatment plant
SWPPP	Stormwater Pollution Prevention Plan
TAPS	Trans-Alaska Pipeline System
TLSA	Teshekpuk Lake Special Area
UIC	underground injection control
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDOT	U.S. Department of Transportation
VSM	vertical support member
WPF	Willow processing facility
WOC	Willow Operations Center
WOUS	Waters of the U.S.

Glossary Terms

Culvert Battery – A group of two or more culverts.

Extended Reach Drilling – A directional drilling technique used to develop long, horizontal wells allowing a larger area to be reached from one surface location (pad) and providing greater access to a reservoir.

Gas Lift – Natural gas reinjected into oil producing formations to aid in maintaining reservoir pressure and oil recovery from the target reservoir.

Hydraulic Fracturing – A well stimulation technique that uses a specially blended fluid that is pumped into a well under extreme pressure causing cracks in the underground reservoir formation. These cracks in the rock allow oil and natural gas to flow, increasing resource production and recovery. Water and sand typically make up 98% to 99.5% of the fluid used in this technique.

Pile Supported – Structures (e.g., buildings, bridges) constructed on columns (i.e., piles) driven into the ground to carry the vertical load.

Screeding – A process which recontours sediment on the marine floor but does not remove sediment from the water. The activity often entails dragging a metal plate such as a screed bar across the sediment, thereby smoothing the high spots and filling the relatively lower areas. The amount of material moved is generally small and localized and the result is a flat seafloor within the work area. Screeding is necessary to temporarily ground the sealift barges during module offloading; a flat seafloor provides stability and prevents damage to the barge hulls during grounding.

Subsistence – A traditional way of life in which wild renewable resources are obtained, processed, and distributed for household and community consumption according to prescribed social and cultural systems and values.

1.0 INTRODUCTION

The Bureau of Land Management (BLM) is the federal manager of the National Petroleum Reserve in Alaska (NPR-A) and is responsible for land use authorizations on federal land within the NPR-A. The BLM is the lead federal agency for the National Environmental Policy Act (NEPA) review of the Willow Master Development Plan (MDP) Project (Project), as proposed by ConocoPhillips Alaska, Inc. (CPAI; the Project proponent); Figure D.1.1 provides an overview of the Project area with all action alternatives. Additionally, the U.S. Army Corps of Engineers (USACE) is a cooperating agency that has jurisdiction over the Project through its authority to issue or deny permits for the placement of dredge or fill material in Waters of the U.S. (WOUS), including wetlands. Both the NEPA evaluation and USACE's permit review require consideration of project alternatives. This appendix provides a detailed overview of the alternatives development process used by the BLM and cooperating agencies, alternative concepts considered and initially evaluated but eliminated from detailed analysis, and the three action alternatives discussed in the Environmental Impact Statement (EIS).

2.0 REGULATORY SETTING FOR ALTERNATIVES ANALYSIS

NEPA directs federal agencies to "study, develop, and describe appropriate alternatives to recommend courses of action in any proposal that involves unresolved conflicts concerning alternative uses of available resources…" (42 USC 4332)). In determining the alternatives to be considered in satisfying the proposed project's purpose and need, the emphasis is on what is reasonable rather than whether the Project proponent likes or is itself capable of implementing an alternative (40 CFR 1502.14). "Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" (CEQ 1981).

Guidelines developed under Section 404(b)(1) of the Clean Water Act direct USACE to use the overall project purpose (based on the Project proponent's stated purpose and need) to define alternatives and determine whether the Project proponent's proposed project is the least environmentally damaging practicable alternative (LEDPA) prior to making a permit decision. The USACE determines whether an alternative is practicable based on whether it is available and capable of being implemented after taking into consideration cost, existing technology, and logistics, in light of the overall project purpose (40 CFR Section 230.3(q)). Throughout the process, other cooperating agencies also provided input into alternatives development.

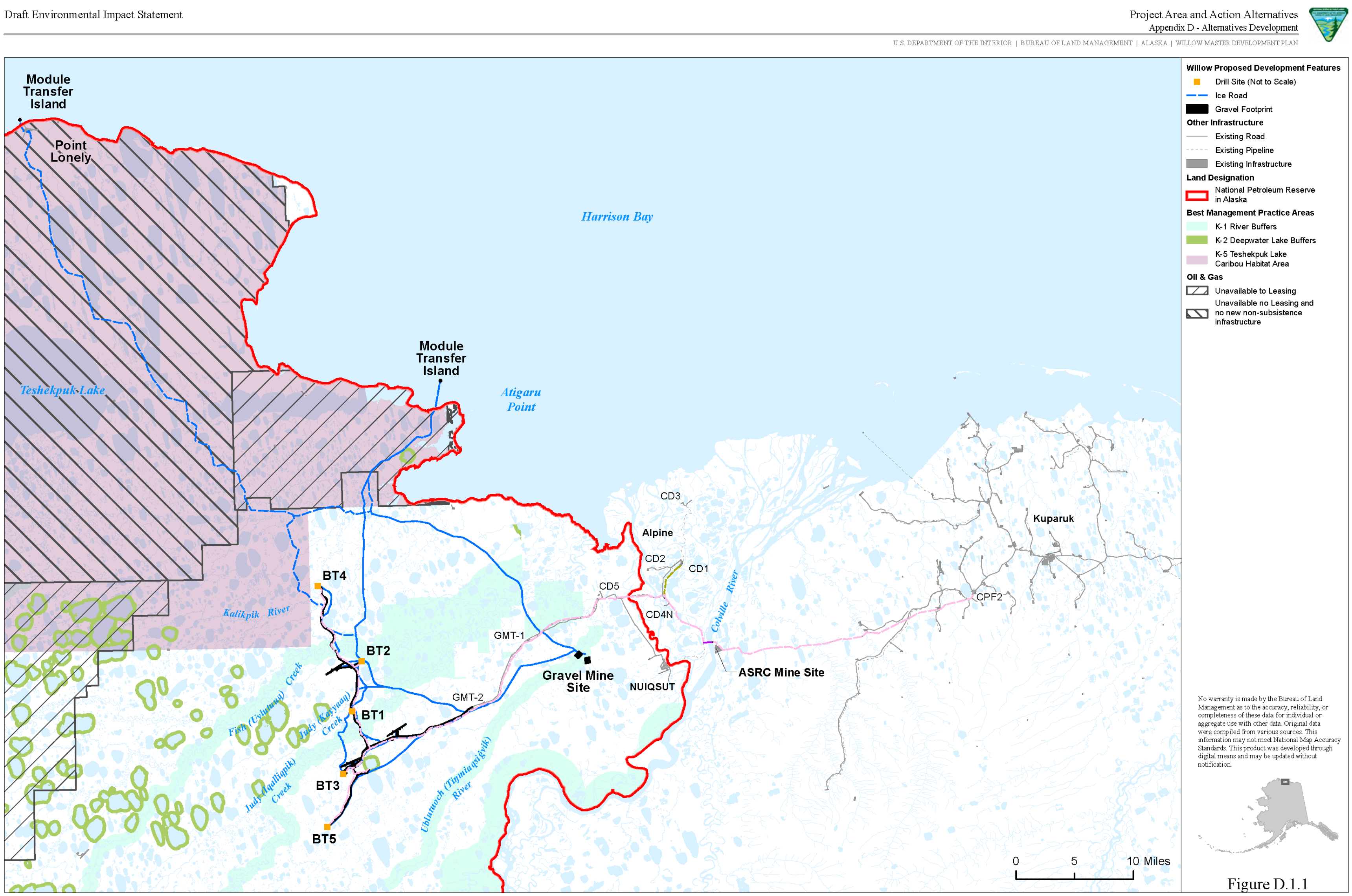

Figure D.1.1. Project Area and Action Alternatives

2.1 Lease Stipulations and Existing Best Management Practices in the National Petroleum Reserve in Alaska

Activity in the NPR-A is subject to a variety of lease stipulations and best management practices (BMPs) intended to reduce effects from development activity; these stipulations and BMPs are detailed in the 2013 NPR-A Integrated Activity Plan (IAP) Record of Decision (ROD) (BLM 2013). Many of the previously identified stipulations and BMPs are readily incorporable into the Project, though some stipulations and BMPs may require exceptions or deviations due to technical constraints and would be evaluated by the BLM on a case-by-case basis. Deviations and exceptions from lease stipulations and BMPs are further discussed in the relevant sections for each action alternative.

Table D.2.1 lists Lease Stipulations (LS) and BMP categories and some relevant LS and BMP designations from the 2013 NPR-A IAP ROD anticipated to be applicable for the Willow MDP EIS.

Table D.2.1. Applicable Lease Stipulations and Best Management Practices

Category	Lease Stipulations and Best Management Practices
Waste handling and disposal	A-1, A-2, A-7
Fuels and hazardous materials handling and storage; spill prevention and spill response	A-3, A-4, A-5
Health and safety	A-8, A-11, A-12
Air quality	A-9, A-10
Water use	B-1, B-2
Winter overland moves	C-1, C-2, C-3, C-4
Facility design and construction	E-1, E-2, E-3, E-4, E-5, E-6, E-7, E-8, E-9, E-10, E-11, E-12, E-13, E-14, E-17, E-18, E-19
Aircraft use	F-1
Oilfield abandonment	G-1
Subsistence	H-1, H-3
Worker orientation	I-1
Biologically sensitive areas	K-1, K-2, K-6, K-7
Summer vehicle tundra access	L-1
General wildlife and habitat protection	M-1, M-2, M-3, M-4

Source: BLM 2013

Likely deviations include LS E-2 and five BMPs: E-5, E-7, E-11, K-1, and K-2. Each identified deviation would be reviewed as the Project design engineering advances for opportunities to conform to lease stipulations and BMPs to the extent practicable. (See Section 4.2.12, *Compliance with Bureau of Land Management Lease Stipulations, Best Management Practices, and Supplemental Practices*, for additional details on the objective and requirements and standards for each BMP and the reason for deviation.)

3.0 ALTERNATIVES DEVELOPMENT

3.1 Overview of the Alternatives Development Process

Regulations governing NEPA state that the alternatives section "is the heart of the environmental impact statement" (40 CFR 1502.14). The regulations require federal agencies to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." The Council on Environmental Quality (CEQ) guidance in NEPA's Forty Most Asked Questions (CEQ 1981) states the following:

> *In determining the scope of alternatives to be considered, the emphasis is on what is "reasonable" rather than on whether the proponent or applicant likes or is itself capable of carrying out a particular alternative. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant.*

The process used to develop a reasonable range of alternatives for analysis in the EIS included five steps:

1. Develop an initial range of potential alternatives
2. Develop screening criteria
3. Evaluate potential alternatives against the screening criteria
4. Document rationale for those alternatives considered but eliminated from further analysis in the EIS
5. Carry remaining alternatives forward as a reasonable range of alternatives for full analysis in the EIS

Key components necessary to meet the Project's purpose and need include drill sites, processing facilities, pipelines, Project area access, gravel source(s), and other support infrastructure.

Following Project scoping, BLM convened a series of alternatives development meetings with EIS cooperating agencies. These meetings identified a range of options for various project components to address issues identified during scoping. These initial options included various configurations for Project components and access. Options identified during the cooperating agency alternatives development meetings included eliminating some roads, use of different airstrips, alternatives to the module transfer island (MTI), different pad locations, and use of other central processing facilities.

3.1.1 Alternatives Screening Criteria

BLM and EIS cooperating agencies developed alternatives screening criteria and used them in evaluating potential alternatives and developing the range of reasonable alternatives. The four basic criteria included:

1. Purpose and need: Alternatives that did not meet the overall Project's purpose were eliminated from further analysis in the EIS.
2. Feasible and practicable: Alternatives that clearly are not feasible or are impractical from a technological or economic standpoint were eliminated from further analysis in the EIS.
3. Substantive issues: Alternatives advanced for analysis in the EIS specifically addressed substantive issues identified during public and agency scoping.
4. Relative environmental effects: Feasible alternatives that would not reduce adverse environmental effects or address resource conflict when compared with the proponent's proposed project were eliminated from further analysis in the EIS.

Additional considerations for screening alternatives included:

- Sufficiently unique: The alternative should be sufficiently unique from other alternatives being evaluated to address resource issues or conflicts that are not already being addressed.
- Future development: The alternative should have the potential to support reasonably foreseeable future development.

3.1.1.1 Purpose and Need

The purpose of the Project proponent's Proposed Action is to construct the infrastructure necessary to allow the safe production and transportation to market of federal oil and gas resources under leaseholds in the northeast area of the NPR-A, consistent with the proponent's Federal Oil and Gas lease and unit obligations. The need for federal action (i.e., the issuance of authorizations) is established by the BLM's responsibilities under various federal statutes, including the Naval Petroleum Reserves Production Act (NPRPA), as amended; the Mineral Leasing Act; and the Federal Land Policy and Management Act, as well as various federal responsibilities of cooperating agencies under other statutes, including the Clean Water Act. Under NPRPA, the BLM is required to conduct oil and gas leasing and development in NPR-A (42 USC 6506a).

3.1.1.2 Feasible and Practicable

The CEQ (1981) guidance expands on 40 CFR 1502.14 (Alternatives Including the Proposed Action) and states that "reasonable alternatives" are "those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" (CEQ 1981). The Project's EIS will also be used by the USACE for its NEPA evaluation. The USACE will issue a ROD for the Project, and the USACE's requirements to select the LEDPA require consideration of practicability during alternatives development. USACE 404(b)(1) guidelines use the term "practicable" and define it as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes" (40 CFR 230). Although the "practicable" threshold under USACE's 404(b)(1) guidelines may be thought of as a more specific and finer filter than the broader "reasonable" threshold from the CEQ guidance, the intent was to not separate or exclude reasonable options under either definition. Therefore, considering the broader CEQ guidance (CEQ 1981), and more specific 404(b)(1) guidance (40 CFR 230), the screening criteria were developed to consider feasibility in terms of cost, logistics, and technology, as well as common sense. These are further defined below:

- Cost feasibility: Alternatives should not involve components with potential costs that would render the project infeasible. (Clean Water Act regulations cite cost as one of the considerations to be factored into determining whether an alternative is practicable.)
- Logistical feasibility: Alternatives should consider whether there are any constraints to development in terms of location, infrastructure, laws, regulations, ability to be permitted, ordinances, or topography.
- Technological feasibility: Alternatives should not involve components that use uncertain or unavailable technology or introduce an increased risk of operational failure or accidents. Certain aspects of an alternative component may have technical constraints affecting the ability to practicably implement those components.

3.1.1.3 Substantive Issues

The BLM identified substantive issues to be addressed in the Project EIS through public and agency scoping and consultation with Alaska Native tribes and Alaska Native Claims Settlement Act corporations. Substantive issues identified during scoping included those that would have significant effects, those that are necessary to make a reasoned choice among alternatives, or those that are needed to address points of disagreement, debate, or dispute regarding an anticipated outcome from a Project action. Table 1.5.1 (Willow MDP EIS, Chapter 1.0, *Introduction and Purpose and Need*) summarizes the substantive issues within the scope of the EIS that were identified through scoping and are addressed in the EIS.

3.1.1.4 Relative Environmental Effects

The EIS evaluates alternatives for their impacts on the physical, biological, and social environments. Feasible alternatives resulting in less adverse environmental effects or addressing resource conflicts when compared to the proponent's proposed project were advanced for further analysis in the EIS. Considerations for relative environmental effects were based on substantive issues raised during scoping. These included potential effects on terrestrial wildlife (including caribou), **subsistence**, public safety, human health, socioeconomics (general and Nuiqsut specific), air quality, the Teshekpuk Lake Special Area, and climate change. Therefore, the development of reasonable alternatives considered the potential for each alternative to:

- Reduce the overall Project footprint (i.e., direct impacts from facilities)
- Reduce potential human health impacts (especially those relating to air quality and subsistence)
- Reduce impacts to wildlife, subsistence resources (especially caribou), and subsistence use areas
- Reduce risks related to spills or other accidental releases
- Reduce impacts to water resources and floodplains, including marine habitat

The four screening criteria guided the alternatives development process and provided a basis for eliminating unreasonable or impracticable options through an independent and structured process.

3.1.2 Alternative Components Considered during Alternatives Screening Process

This section provides an overview of the alternative components considered during alternatives development. Alternative components are organized by the Project component being addressed: access, airstrip, MTI, gravel mine site, gravel pads, and processing facility. Table D.3.1 summarizes the 32 options considered during alternatives development (not including the No Action Alternative [Alternative A]and Alternative B: Proponent's Project). Additional alternative components evaluated and dismissed by CPAI were reviewed by BLM during the alternatives development process and dismissed due to screening criteria; these are described in CPAI's Environmental Evaluation Document (CPAI 2018) and include use of the Alpine processing facility, **pile supported facilities**, roadless drill sites, not constructing an airstrip, and more.

3.1.2.1 Access Options

Several options were considered to reduce the Project's impacts related to access road development. Reducing new road infrastructure would lessen direct impacts from road construction and gravel mining requirements. A reduced road footprint would reduce direct impacts to WOUS, including wetlands, hydrological resources and connections, and potential impacts to wildlife, especially caribou.

Access options include making certain segments of the Project "roadless" (i.e., no gravel road but connections with ice roads), constructing a bridge across the Colville River, and relocation of road segments, including bridges.

Each of the access options is described in Table D.3.1.

3.1.2.2 Airstrip Options

Options were considered to use existing airstrips in the area (3 total) and to integrate the gravel road with the airstrip. These options were aimed at reducing impacts from air traffic and construction of a new Project area airstrip (e.g., fill of WOUS, impacts to subsistence and wildlife).

Each of these airstrip options is described in Table D.3.1.

3.1.2.3 Module Delivery Options

The Project would require a sealift (ocean-going barge) to deliver pre-fabricated modules to the North Slope, and CPAI has proposed the construction of a gravel island in Harrison Bay (near Atigaru Point) to receive the module shipments before transferring them to the Project area via ice road. The alternatives analysis also identified Point Lonely as an alternative location for island construction.

Multiple options to eliminate or modify the proposed MTI were considered during alternatives development to reduce impacts to the marine environment and the presence of infrastructure in subsistence use areas. Each of the module delivery options is described in Table D.3.1.

3.1.2.4 Mine Site Options

The Project would require approximately 4.7 to 5.2 million cubic yards (cy) of gravel to complete construction of proposed infrastructure (volume varies by alternative). One alternative to the CPAI's proposal was considered during alternatives development, and BLM later requested that CPAI examine a second alternative related to the methods for gravel mining production that would eliminate or reduce the need to use traditional blasting (i.e., explosive) methods. These alternatives were considered to reduce impacts to habitat (e.g., creation of a new mine site) and the community of Nuiqsut (e.g., noise).

Each of the blasting options is described in Table D.3.1.

3.1.2.5 Gravel Pads Options

A total of four options for gravel pads was considered during alternatives development. Suggested options for pads ranged from reducing pad size, altering pad locations, and reducing the overall number of pads. These options were aimed at reducing impacts to wetlands and vegetation.

Each of these options is described in Table D.3.1.

3.1.2.6 Processing Facility Options

Two options were suggested as an alternative to constructing a Project-specific processing facility to reduce potential impacts to air quality and impacts to wetlands and vegetation from the construction of additional Project infrastructure. Each of these processing facility options is described in Table D.3.1.

3.1.2.7 Schedule

Two options were suggested as alternatives related to the timing or schedule of how the Project would be executed. These alternatives were aimed at reducing impacts to subsistence users. Each of these schedule options is described in Table D.3.1.

Table D.3.1. Alternative Components Considered during Alternatives Development

Component Category	Component Number	Alternative Component Considered	Description	Why Considered
All	1	No action alternative	No action; carried forward as Alternative A in the EIS.	NEPA requirement to serve as a baseline of comparison for impact analysis
All	2	Proponent's proposed project	Project as proposed by CPAI; carried forward in the EIS as Alternative B.	CPAI's proposed action
Access	3	No gravel road connections to drill sites BT2 and BT4	This alternative would not include a gravel road connection to drill sites BT2 and BT4 (i.e., the gravel road connection would stop at drill site BT1); instead, access to these drill sites would be via aircraft and seasonal ice road.	Reduce footprint/fill Reduce number of stream crossings Reduce impacts to caribou movement
Access	4	Construct a permanent bridge over the Colville River	Construct a permanent bridge over the Colville River to provide a year-round gravel road connection between the Project area and the Alaska highway system; use smaller sealift modules and deliver them to the Project area from Oliktok Dock via gravel or ice roads.	Eliminate the need for the module transfer island Reduce annual water consumption required for ice road construction Reduce air traffic to Alpine and Project area
Access	5	Construct a boat ramp on the Colville River	This alternative component would construct a boat ramp/launch on the Colville River and would provide a connection to year-round road access (e.g., Dalton Highway).	Subsistence access
Access	6	Make drill site BT4 roadless	This alternative component would make drill site BT4 disconnected (i.e., no gravel road connection) from the rest of the Project and allow connection by ice road during the winter and by aircraft during the remainder of the year.	Reduce impacts to caribou movement Reduce footprint/fill Reduce the number of stream crossings
Access	7	Relocate the Judy (Iqalliqpik) Creek Bridge crossing (as designed by CPAI in its proposed Alternative 2 (CPAI 2018)	This alternative component would relocate the Judy (Iqalliqpik) Creek Bridge crossing location as proposed by CPAI in Alternative 2 to an area that would allow a shorter crossing of the creek (1,850 feet long as proposed).	Reduce impacts to Judy (Iqalliqpik) Creek (e.g., fish, subsistence, hydrology) Reduce impacts to yellow-billed loons (*Gavia adamsii*)
Access	8	Roadless access to the Willow processing facility and make drill site BT4 roadless	This alternative would use only a seasonal road (e.g., ice road) connection for Project access and to access drill site BT4.	Reduce impacts to caribou movement Reduce footprint/fill Reduce number of stream crossings

Component Category	Component Number	Alternative Component Considered	Description	Why Considered
Access	9	Relocate Judy (Iqalliqpik) Creek Bridge crossing and reroute the road (as designed by CPAI in its proposed Alternative 2 (CPAI 2018)	This alternative would relocate the Judy (Iqalliqpik) Creek Bridge crossing location and reroute the gravel road; departing from the Willow processing facility, the road would cross Judy (Iqalliqpik) Creek to the west before heading to drill sites BT2 and BT4 with a spur road to drill site BT1.	Reduce impacts to Judy (Iqalliqpik) Creek (e.g., fish, subsistence, hydrology) Reduce impacts to yellow-billed loons
Airstrip	10	Use the existing Alpine airstrip	Use the existing Alpine airstrip and do not construct a new airstrip in the Project area.	Centralize air traffic in an area with existing air traffic Reduce footprint/fill Maximize the use of existing infrastructure
Airstrip	11	Use the existing Nuiqsut airstrip	Use the existing Nuiqsut airstrip and do not construct a new airstrip in the Project area. This would require the construction of a new gravel road to the Project area (or GMT-2), or an access agreement to use the privately owned (Kuukpik Corporation) Nuiqsut Spur Road.	Centralize air traffic in an area with existing air traffic outside of the Colville River Delta Reduce footprint/fill Socioeconomic benefit to Nuiqsut Maximize the use of existing infrastructure
Airstrip	12	Use the existing Inigok airstrip	Use the existing Inigok airstrip and do not construct a new airstrip in the Project area. This would require the construction of a new gravel road to the Project area extending approximately 20 miles to the northwest.	Move air traffic further away from Nuiqsut Reduce footprint/fill Maximize the use of existing infrastructure
Airstrip	13	Integrate the proposed airstrip and roadway	Integrate a portion of the parallel gravel road into the proposed airstrip resulting in a dual-use facility.	Reduce footprint/fill
MTI	14	Use small-size sealift modules (550 tons or less) for the Willow processing facility	Use small-size sealift modules (550 tons or less; module transporters would be 100 tons) to construct the Willow processing facility so modules can be delivered to Oliktok Dock and transported to the Project area over terrestrial ice roads and cross the Colville River seasonal ice bridge (maximum load capacity is 650 tons).	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users) Reduce water consumption
MTI	15	Use medium-size sealift modules (1,400 tons or less) for the Willow processing facility	Use medium-size sealift modules (1,500 tons or less) to construct the Willow processing facility so modules can be delivered to Oliktok Dock and transported to the Project area over a combination of sea-ice and terrestrial-based ice roads.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users)

Component Category	Component Number	Alternative Component Considered	Description	Why Considered
MTI	16	Freeze sealift barges in place in Harrison Bay	This alternative component would ground sealift barges in Harrison Bay (in the same location of the proposed MTI) during the open-water season and allow them to freeze in place during winter.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users)
MTI	17	Reduce the life span of the MTI	The MTI is proposed to be used for two distinct periods (2 consecutive years to support Willow processing facility and drill site module delivery and 1 additional year to support drill site modules); this option would eliminate the second period of module delivery to the MTI (and instead use smaller modules delivered to Oliktok Dock), which would allow for decommissioning of this Project facility sooner.	Reduce the lifespan of the MTI to reduce the length of time for impacts to the marine environment and subsistence users
MTI	18	Make the MTI semi-permanent	The MTI would be constructed with the intent of being maintained for an extended time beyond the length identified as needed for the Project. This would allow future development (by CPAI or others) in the area to use the facility and not require construction of a similar feature.	Increasing the lifespan of the MTI could potentially reduce the cumulative impacts associated with future development May provide usable infrastructure to local subsistence users
MTI	19	Land sealift barges at shore near Atigaru Point	This alternative component would ground sealift barges near the shoreline in Harrison Bay during the open water season and allow them to freeze in place during winter.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users)
MTI	20	Construct a dock at Atigaru Point	This alternative component would construct a new industrial dock facility at Atigaru Point (located in Harrison Bay) for the delivery of sealift modules during the open-water season.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users) Reduce potential cumulative impacts from future development May provide usable infrastructure to local subsistence users

Component Category	Component Number	Alternative Component Considered	Description	Why Considered
MTI	21	Construct a dock at Point Lonely	This alternative component would construct a dock at Point Lonely and use the existing infrastructure from this decommissioned U.S. Department of Defense site for the off-loading and staging of sealift modules.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users) Maximize use of existing infrastructure
MTI	22	Construct an MTI at Point Lonely	This alternative component would construct a gravel island at Point Lonely to receive the sealift modules during the open-water season. The existing infrastructure at Point Lonely would be used to stage equipment (e.g., ice-road–making equipment, personnel camp).	Eliminate the MTI at Atigaru Point (i.e., reduce impacts to Nuiqsut subsistence users) Maximize use of existing infrastructure
MTI	23	Deliver sealift modules to the Project area via a grounded-ice bridge over the Colville River near Umiat	Deliver medium-size or large-size sealift modules to Oliktok Dock and transfer them to the Project area via ice roads with a crossing of the Colville River on a grounded-ice bridge, south of the Project area near Umiat.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users) Maximize use of existing infrastructure
MTI	24	Construct a dock at the abandoned Kogru River pad	This alternative component would construct a dock at an abandoned pad site along the Kogru River.	Eliminate the need for the MTI (i.e., reduce impacts to the marine environment and subsistence users) Maximize use of existing infrastructure
Mine site	25	Use the existing Arctic Slope Regional Corporation mine site	Use the existing commercial Arctic Slope Regional Corporation mine site near Nuiqsut to supply gravel for the Project instead of constructing a new project-specific gravel mine site.	Consolidate gravel mining operations to a single, existing mine site (i.e., maximize use of existing infrastructure)
Mine site	26	Alternatives to traditional blasting to support gravel mining operations	Examine alternative methods for gravel mining (e.g., mechanical extraction) that would eliminate or reduce the use of blasting with conventional explosives.	Reduce noise impacts to wildlife, Nuiqsut residents, and subsistence activities
Pads	27	Reduce the number and/or size of drill site pads	Reduce the overall number of proposed project drill site pads or reduce the size of individual pads.	Reduce footprint/fill
Pads	28	Reduce the size of pads by using pile-supported facilities	Use pile-supported structures where practicable (e.g., camps, cold storage) instead of placing structures at grade on gravel pads.	Reduce footprint/fill
Pads	29	Relocate drill site BT4 from its proposed location to an area outside of the K-5 Teshekpuk Lake Caribou Habitat area	Relocate drill site BT4 out of the proposed location within the K-5 Teshekpuk Lake Caribou Habitat area.	Reduce impacts to caribou Reduce the number of stream crossings

Component Category	Component Number	Alternative Component Considered	Description	Why Considered
Pads	30	Move drill site BT2 westward and away from Fish (Uvlutuuq) Creek	Relocated drill site BT2 westward and away from Fish (Uvlutuuq) Creek.	Avoid Fish (Uvlutuuq) Creek buffer (BMP K-1) Reduce impacts to fish Reduce impacts to subsistence use
Processing facility	31	Use the Alpine processing facility instead of constructing a Project-specific processing facility	Use the existing Alpine processing facility instead of constructing a project-specific processing facility in the Project area.	Centralize processing activity at an existing facility Maximize the use of existing infrastructure Reduce footprint/fill
Processing facility	32	Relocate the Project processing facility closer to the GMT Unit boundary	Relocate the proposed Willow processing facility further to the northeast, closer to the GMT Unit boundary.	Reduce impacts to caribou
Schedule	33	Phase development of the Project so construction does not begin until the GMT-2 development is constructed and is in its drilling/operations phase	Institute phasing to begin Project construction after GMT-2 has been constructed and has advanced to the drilling/operations phase so impacts from GMT-2 can be better identified and addressed in the Project.	Provide additional insight into potential effects to environmental resources that may be addressable in the Project Reduce cumulative impacts in area
Schedule	34	Delay the Project EIS until after GMT-2 is in the drilling/operations phase	Delay the development of the Project EIS until after GMT-2 development is in its drilling/operations phase so the impacts from the GMT-2 project would be known and could be further addressed in the design and plans for the Project.	Provide additional insight into potential effects to environmental resources which may be addressable in the Project Reduce cumulative impacts in area

Note: BT (Bear Tooth); BT1 (drill site BT1); BT2 (drill site BT2); BT4 (drill site BT4); CPAI (ConocoPhillips Alaska, Inc.); EIS (Environmental Impact Statement); GMT (Greater Mooses Tooth); GMT-2 (Greater Mooses Tooth 2); MTI (module transfer island); NEPA (National Environmental Policy Act)

3.1.3 Alternative Components Considered but Eliminated from Further Analysis

As previously described, the BLM and the cooperating agencies considered a range of alternative components for various Project components (access, airstrip, MTI, mine site, pads, and processing facility). A total of 32 alternative components (excluding the No Action Alternative and the Proponent's Proposal) were evaluated to determine whether they were reasonable in light of the Project's purpose. Of these, 25 alternative components were eliminated from further analysis because they did not meet the overall Project purpose, were not considered economically or technically feasible or practicable (as defined by CEQ [1981] guidelines), did not address substantive issues raised during scoping, did not provide benefits over an alternative already being considered, or were determined to be more appropriate as potential mitigation or minimization measures. After the alternative components were evaluated against the screening criteria, they were either 1) eliminated or 2) incorporated into an action alternative to be carried forward for analysis in the EIS. Alternatives components considered but eliminated from further analysis are summarized in Table D.3.2, along with the rationale for elimination.

Table D.3.2. Alternative Components Considered but Eliminated from Further Analysis and the Rationale for Elimination[1]

Component Number	Alternative Component Considered	Rationale for Elimination
3	Access – No gravel road connections to drill sites BT2 and BT4	Would result in 26 to 30 acres of additional surface disturbance (i.e., wetland fill) for additional airstrip, camp, and equipment and supply storage at each drill site. Would result in substantial additional water use over the life of the Project to annually construct resupply ice roads from drill site BT1 to drill sites BT2 and BT4. Would result in additional air traffic during the 9-month roadless period each year (would increase air traffic by approximately 7,000 flights during construction and 1,100 flights during drilling and operations). Would increase health and environmental risk in the event of an emergency (i.e., inability to evacuate personnel or respond to oil spill incidents when weather prevents flights in and out of the airstrips, which is common on the North Slope).
4	Access – Construct a permanent bridge over the Colville River	This alternative component would not reduce environmental impacts (would likely increase impacts to caribou, subsistence, and wetlands/Waters of the U.S.). Substantial technical and economic feasibility constraints make this alternative not practicable under the U.S. Army Corps of Engineers Section 404 regulations. Construction of a permanent bridge over the Colville River is not part of the Project's purpose and need.
5	Access – Construct a boat ramp on the Colville River	Construction of a boat ramp on the Colville River would not provide increased access to the Project area for CPAI.
6	Access – Make drill site BT4 roadless	Would result in increased surface disturbance (need for additional airstrip, storage, and camps). Would increase health and environmental risk in the event of an emergency (i.e., inability to evacuate personnel or respond to oil spill incidents when weather prevents flights in and out of the airstrips, which is common on the North Slope). Would increase air traffic near the K-5 Teshekpuk Lake Caribou Habitat area during the 9 months annually when ice roads would not be available (air traffic would increase by approximately 3,500 flights during construction and 550 flights during drilling and operations).
8	Access – Roadless access to the Willow processing facility and make drill site BT4 roadless	Would not appreciably reduce impacts beyond advanced alternatives, Alternative C: Disconnected Infield Roads or Alternative D: Disconnected Access. Would increase air traffic at drill site BT4 near the K-5 Teshekpuk Lake Caribou Habitat area during the 9 months annually when ice roads would not be available (air traffic at this drill site would increase by approximately 3,500 flights annually during construction and 550 flights during drilling and operations).

[1] Any impact comparisons provided in Table D.3.2 are made in reference to CPAI's proposed project (Alternative B: Proponent's Project) unless otherwise indicated.

Component Number	Alternative Component Considered	Rationale for Elimination
10	Airstrip – Use the existing Alpine airstrip	Would substantially increase air traffic at the Alpine airstrip, which is sited in the Colville River Delta, an area that both resource agencies and Nuiqsut community members have noted is a more environmentally sensitive area (e.g., wildlife, subsistence use) than the Project area. Cooperating agencies emphasized that increased impacts in the Colville River Delta should be avoided. Use of the Alpine airstrip would increase air traffic at Alpine by approximately 700 flights per year during construction and would increase vehicle traffic through the GMT and Alpine developments. Would require upgrades to the Alpine airstrip and construction of an additional bypass road, as the integrated road and airstrip at Alpine would no longer be logistically feasible with the amount of air and vehicle traffic from both projects operating concurrently. This would result in additional impacts to wetlands and other environmental resources in the Colville River Delta. Increased vehicle trips and travel times pose a risk to Project employees through increased personnel exposure to potential accidents during transport between Alpine to Willow (an approximately 2-hour drive each way). The additional travel time also increases the risk to personnel in the event an evacuation is required (e.g., medical emergency). For reference, CPAI documented 510 medical evacuations in the Kuparuk and Alpine fields in 2015 and 2016. The Alpine airstrip is located in an area more prone to weather-related flight safety issues (e.g., fog) than the Project area, which poses a number of logistical problems, including safety challenges related to weather limitations. Increasing the number of flights at this airstrip would only exacerbate current weather-related delays. This option would not support reasonably foreseeable future development within the Project area.
11	Airstrip – Use the existing Nuiqsut airstrip	Would require improvements and expansion of the existing Nuiqsut airstrip to accommodate traffic, including fill in adjacent wetlands and streams. Would require a gravel road connection to the Project area from Nuiqsut, which would result in additional fill in wetlands. Use of the existing gravel road connection to Alpine from Nuiqsut (Spur Road) would require approval from Kuukpik Corporation for CPAI to use and improve the road (to Project standards). BLM discussed this with the Kuukpik Corporation for the GMT-2 development, and the Kuukpik Corporation denied the request. Would require construction of a new all-season gravel road to connect the Project area with Nuiqsut. Would add additional road traffic in Nuiqsut (or require a new gravel road connection between Nuiqsut and the Project area), which would generate increased, traffic, noise, and dust in the community. There is currently no consensus from the community or Native Village of Nuiqsut about whether they would be in favor of Nuiqsut being an operations hub for oil and gas development.
12	Airstrip – Use the existing Inigok airstrip	This option would not reduce environmental impacts: The Inigok airstrip is located more than 20 miles from the Project area (drill site BT5) and would require upgrades and an additional gravel access road to use it, creating additional impacts to wetlands and other environmental resources (e.g., caribou). The new gravel road to Inigok would be in an area used more heavily by caribou than the proposed road connection from GMT-2 to the Project area, and the road to Inigok would be much longer.

Component Number	Alternative Component Considered	Rationale for Elimination
13	Airstrip – Integrate the proposed airstrip and roadway	Use of an integrated airstrip for both landing aircraft and vehicle traffic creates safety concerns with the number of anticipated flights and volume of vehicle traffic. Integrating the Project airstrip with the road would only reduce impacts to wetlands by 5.5 acres.
14	MTI – Use small-size sealift modules (550 tons or less) for the Willow processing facility	While the smaller module size would eliminate the need for the MTI because modules could be offloaded at Oliktok Dock and transported across the Colville River ice bridge (650-ton max weight limit, including module transporters [approximately 100 tons]), this option is not technically feasible due to the some of the individual module components exceeding the maximum load capacity of the Colville River ice bridge. This alternative component would also increase the overall Project footprint because of the need to construct on-site fabrication facilities to complete module installation and because of safety requirements for individual module separation distance minimums. This alternative component would increase the overall amount of vehicle traffic near Nuiqsut during the already busy ice-road season when the annual Alpine resupply ice road is in operation. Use of small-size sealift modules would require significantly increased labor hours on the North Slope (versus the module fabrication facility located outside of Alaska) which would increase the overall safety exposure of Project personnel on the North Slope where weather conditions are extreme and full medical support is limited to distance locations.

Component Number	Alternative Component Considered	Rationale for Elimination
15	MTI – Use medium-size sealift modules (1,400 tons or less) for the Willow processing facility	While medium-sized modules would eliminate the need for the MTI because modules could be offloaded at Oliktok Dock and use a combination of sea- and tundra-based ice route to deliver the modules to the Willow processing facility pad, additional environmental impacts and Project execution risks would occur. Existing and planned gravel infrastructure size would increase 19 acres using 73,500 cubic yards of fill material. This would include the curve straightening of existing roads to accommodate the overall length of the module transporters, the construction of the gravel pad near Fish (Uvlutuuq) Creek in the Colville River Delta, and an increase in the Willow processing facility pad to address safety requirements (resulting from an increase from four modules to 15). The required length and thickness of the ice-road routes to be completed in a single season is at the upper limits of what has been historically constructed in a single winter season on the North Slope. The North Slope does not have enough equipment or personnel capacity to support construction of this route and support other projects by CPAI and other North Slope operators. Due to the design requirements for the sea-ice route and limited window to transport the 15 sealift modules, the sealift module move would occur over two seasons, effectively doubling impacts (e.g., potential marine mammal disturbance, water consumption) and requiring the construction of the staging pad near Fish (Uvlutuuq) Creek in the Colville River Delta. In order to transport the modules (1,800-ton total load with transport vehicles), the sea ice would need to be grounded. In the Colville River Delta, due to year-round flows, the sea ice cannot be grounded, and the floating ice would need to be approximately 25 feet thick to support the move. Should a module break through the ice, Project personnel would be in danger, the module could be lost, and the environmental impacts could be significant. (It is estimated that salvage of a module would take between 1 and 3 years.) The increase transport time would delay Project construction by 1.5 years and first oil by 2 years, making the Project economically unfeasible for CPAI. CPAI has notified the BLM that due to the risk to Project personnel, assets (e.g., sealift modules, support equipment), and the environment from the long sea-ice route, this option is unfeasible and could not be implemented if selected as the preferred alternative in the Willow Master Development Plan Environmental Impact Statement.

Component Number	Alternative Component Considered	Rationale for Elimination
16	MTI – Freeze sealift barges in place in Harrison Bay	The freeze-in barge concept was evaluated by a team of engineers, including specialist in ice engineering, cold-region engineering, Arctic marine naval architects, geothermal engineering, and offshore geotechnical engineering to determine risks and potential mitigation measures to reduce risks. The analysis determined the concept of freezing the sealift modules in place was not practical or feasible from a technological standpoint and presented significant risks to the environment, personnel safety, and modules (CPAI 2019). Identified ice loading on the barge structure could readily lead to a loss of barge structural integrity. Mitigation measures to counter structural loading included using supplemental refrigeration to freeze ballast water in the barge holds; structural reinforcement of existing barges and custom-built ice-class barges; and construction of ice- or gravel-berm protective barriers. Each of these mitigation measures still presented operational risks and uncertainty of varying degrees, including risk to human safety and asset protection. Barge anchoring (i.e., preventing ice loads from moving the barges after they have been grounded to the seafloor) presented additional challenges that engineering design could not mitigate. Mitigation measures included tying/connecting the five barges together as a single unit; installing pipe piles to further anchor the barges to the grounded location; and dredging the grounding site to reach more resistant (to sliding) soils. In the event of a barge structural event, significant ice formation on the modules (i.e., spray accumulation on the module creating uneven loading) or ice pileups against the loaded barges, could result in a module or barge (or both) sinking in Harrison Bay. Such an event would create a significant risk to Project personnel and would result in a significant salvage operation with potential for serious environmental impacts.
17	MTI – Reduce the life span of the MTI	The module delivery options (Proponent's MTI or Point Lonely MTI) have been designed to accommodate two distinct sealifts: the first delivering the Willow processing facility modules and three drill site modules (BT1, BT2, and BT3); the second sealift would deliver two drill site modules (BT4 and BT5). Drill site module design and detailed engineering is not anticipated to be completed until at least 2020. If the drill site module design can produce sealift modules weighing less than 650 tons (with module transporters), CPAI could deliver the sealift modules to Oliktok Point and transport them to the Project area via a combination of ice and gravel roads. (This route would require crossing the Colville River ice bridge, which has a maximum weight rating of 650 tons.) At the current time, this alternative component has been eliminated from consideration in the EIS as its implementation is speculative; however, should CPAI determine that this is technically and logistically feasible, Project plans could be updated with the BLM and the MTI could be decommissioned earlier than proposed.
18	MTI – Make the MTI semi-permanent	CPAI has not identified any reasonably foreseeable future projects that would require sealift module delivery in the National Petroleum Reserve in Alaska and has no need for the proposed MTI following Project construction. The MTI would be located in State of Alaska waters (for both the Proponent's MTI and Point Lonely MTI), and the State of Alaska has expressed no interest in taking ownership of the MTI following Project construction. Since the MTI will require annual inspection and maintenance as needed (e.g., gravel bag armor replacement) and there is no other identified entity to take possession and responsibility for the MTI, this alternative option has been eliminated as not being technically feasible.

Component Number	Alternative Component Considered	Rationale for Elimination
19	MTI – Land sealift barges at shore near Atigaru Point	Landing sealift module barges at the shore would require dredging approximately 2.5 miles of seafloor (approximately 100 acres) to a depth of approximately 11.5 feet to 14.5 feet, creating greater impacts to the marine environment than the Proposed Action. Significant dredging activity has been identified by local stakeholders (e.g., Nuiqsut subsistence users) as being overly disruptive to subsistence activity.
20	MTI – Construct a dock at Atigaru Point	Construction of a dock at Atigaru Point would have greater impacts to the marine environment and wetlands/Waters of the U.S.: For marine vessels to reach shore, dredging would be required for approximately 2.5 miles of seafloor (approximately 100 acres) to a depth of approximately 11.5 feet to 14.5 feet, creating greater impacts to the marine environment then the Proposed Action. Significant dredging activity has been identified by local stakeholders (e.g., Nuiqsut subsistence users) as being overly disruptive to subsistence activity. Dock facilities would require additional fill to construct gravel pads and the dock in wetlands and Waters of the U.S.
21	MTI – Construct a dock at Point Lonely	Construction of a dock at Point Lonely is not technically feasible due to accelerated rates of shoreline erosion occurring at the site. Annual shoreline erosion at Point Lonely in recent years has accelerated in excess of 80 feet per year. Such shoreline erosion rates where the causeway would connect to the shoreline cannot be adequately addressed through Project planning and engineering design.
23	MTI – Deliver modules to the Project area via grounded-ice bridge over the Colville River near Umiat	U.S. Geological Survey data shows that the Colville River frequently has flowing water year-round. The lowest flow periods are only one month long (April). As such, the Colville River would not have the required conditions There are multiple feeder rivers and streams that would need to be crossed on the approach to Umiat, and they may also not have fully grounded ice. The ice road route would be approximately 115 miles to south Umiat and an additional 50 miles north to reach the Project area. Ice road transit would require a minimum of one multi-season ice pad or gravel pad due to length of route (i.e., module delivery would likely take 2 years to complete).
24	MTI – Construct a dock at the abandoned Kogru River pad	Construction of a dock at the abandoned Kogru River pad would have greater impacts to the marine environment and wetlands/Waters of the U.S.: For marine vessels to reach shore, dredging would be required for approximately 9 miles of seafloor (approximately 370 acres) to a depth of ranging from 11.5 feet to 14.5 feet, creating greater impacts to the marine environment than the Proposed Action. Significant dredging activity has been identified by local stakeholders (e.g., Nuiqsut subsistence users) as being overly disruptive to subsistence activity. Dock facilities would require the placement of additional fill to construct gravel pads in wetlands and Waters of the U.S.

Component Number	Alternative Component Considered	Rationale for Elimination
25	Mine site – Use the existing Arctic Slope Regional Corporation mine site	Use of this mine site would have greater impacts in Nuiqsut than the proposed mine site as the Arctic Slope Regional Corporation mine site is approximately half the distance to Nuiqsut: Blasting activity would have greater impacts. Gravel hauling would also occur through or near the community, creating additional noise and air quality impacts in the Nuiqsut. The Arctic Slope Regional Corporation mine site is further from the Project area and would increase round trip gravel hauling operation by approximately 20 miles per load.
26	Mine site – Alternatives to blasting to support gravel mining operations	CPAI reviewed multiple gravel mining methods as alternatives to blasting at the request of the BLM, including mechanical methods (e.g., crushers, mining saws, terrain levelers, road headers, and continuous miners), steam or thermal thawing, and alternative blasting products (e.g., Autostem products). Of the equipment types requested by the BLM for CPAI to investigate, the majority were not capable of producing mining rates required for the short gravel mining season in the Project area. Previous North Slope operations working on smaller-scale project (e.g., pad work, road work) have employed some of the mechanical methods noted by the BLM with success. However, the equipment has had a history of hydraulic failures at temperatures approach -15° Fahrenheit. Additionally, due to the slower rate of mining production, the mine site would need to be operated year-round, which is not feasible for the Project as the mine site would not be connected by gravel road (mining operations would only occur during winter with ice road access).
27	Pads – Reduce the number and/or size of drill site pads	Would not meet the purpose and need to recover the maximum extent of the targeted hydrocarbon resources. Drill pads have already been optimized to the minimum size needed for the proposed activity. Drill pad locations have already been optimized to provide maximum accessibility to the resources based on existing extended-reach drilling technology and reservoir location and characteristics.
28	Pads – Reduce the size of pads by using pile-supported facilities	Would create safety risks related to emergency egress and access for emergency responders (e.g., firefighters), who only have access to one or two sides of the structure for a portion of the year. Would limit maintenance access and opportunities outside of winter season. Pile-supported modules overhanging tundra that require resupply by truck (e.g., chemical tanks, fuel tanks) would pose an increased risk to the environment in the event of an overfill or spill. Most support facilities (e.g., central processing facility modules, fleet and equipment repair shop, fabrication shop) are designed to have access to all sides of the structures for functionality and to provide space to move material and equipment around safely and efficiently. Would not appreciably reduce impacts to wetlands in comparison with the Proposed Action due to shading effects beneath buildings.

Component Number	Alternative Component Considered	Rationale for Elimination
31	Processing – Use the Alpine processing facility instead of constructing a Project-specific processing facility	The Alpine processing facility does not have capacity to process Project production (peak estimate of 200,000 barrels of oil per day, 175,000 barrels of water per day, and 300 million standard cubic feet of gas per day). The Alpine processing facility is currently at gas handling capacity and the expected production from GMT-1 and GMT-2 will keep the facility at or near capacity for gas and water handling into the 2030s. The Project reservoir pressures are substantially less than those found at the Alpine development, presenting additional challenges to co-processing fluids at the existing facility. Upgrades to increase capacity of the Alpine processing facility would increase overall Project impacts in the Project area and the Colville River Delta, an environmentally sensitive area: Partial processing facilities in the Project area would be required (i.e., although a full central processing facility would not be required, a partial processing facility would still be required). Transport of multiphase fluids to the Alpine processing facility would require additional pumping and heating equipment in the Project area, expanding the gravel footprint within the Project area. The Alpine processing facility would require expansion to process fluids from the Project.
33	Schedule – Phase development of the Project so construction does not begin until GMT-2 development is constructed and is in the drilling/operations phase	This is already accomplished under the action alternatives, including the proponent's proposed action; construction of the 5 Project drill sites over a period of 5 to 7 years (varies by alternative).
34	Schedule – Delay the Project EIS until after GMT-2 is in the drilling/operations phase	BLM is unable to postpone Project permitting based on regulatory requirements applicable to the NPR-A found in 42 USC 6506(a). Deferral of a project authorization would be inconsistent with the directives of the Naval Petroleum Reserve Production Act to expeditiously carry out an oil and gas leasing program. Delayed permitting would be inconsistent with the rights of CPAI acquired with the subject leases to reasonably develop the oil and gas within those lease tracts (generally limited to a 10-year lease term) and with CPAI's obligations in the Bear Tooth Unit Agreement to promptly pursue development.

Note: BT (Bear Tooth); BT2 (drill site BT2); BT4 (drill site BT4); CPAI (ConocoPhillips Alaska, Inc.); CRD (Colville River Delta); GMT-2 (Greater Mooses Tooth 2); MTI (module transfer island); NPR-A (National Petroleum Reserve-Alaska)

3.1.4 Alternative Components Carried Forward

In developing the alternatives to be considered in the Project EIS, several alternative components suggested were incorporated into Alternatives C and D analyzed in the EIS. Additionally, some alternative components were able to be incorporated into all action alternatives (e.g., as a BMP) or are being analyzed in the EIS until a determination on their feasibility is determined.

Table D.3.3 summarizes those alternative components carried forward as either alternatives or standalone components for analysis in the EIS.

Table D.3.3. Alternative Components Considered and How They Are Carried Forward in the Environmental Impact Statement

Component Number	Alternative Component Considered	Description of How Alternative Component is Carried Forward in the Environmental Impact Statement
1	No action alternative	No action; carried forward as Alternative A in the EIS.
2	Proponent's proposed project	Project as proposed by CPAI; carried forward as Alternative B in the EIS.
8	Access – Relocate the Judy (Iqalliqpik) Creek Bridge crossing (as designed by CPAI in its proposed Alternative 2) (CPAI 2018)	All action alternatives with a crossing of Judy (Iqalliqpik) Creek use the same road and bridge alignment. The proposed bridge length has been reduced from 1,850 feet to 420 feet.
10	Access – Relocate the Judy (Iqalliqpik) Creek Bridge crossing and reroute the road (as designed by CPAI in its proposed Alternative 2 (CPAI 2018))	All action alternatives with a crossing of Judy (Iqalliqpik) Creek use the same road and bridge alignment. The proposed bridge length has been reduced from 1,850 feet to 420 feet.
23	MTI – Construct an MTI at Point Lonely	This alternative concept has been carried forward in the EIS as Option 2: Point Lonely Module Transfer Island.
30	Pads – Move drill site BT4 out of the K-5 Teshekpuk Lake Caribou Habitat area	Drill site BT4 has been relocated outside of the K-5 Teshekpuk Lake Caribou Habitat area and east of the Kalikpik River for all action alternatives. CPAI has agreed to apply all K-5 BMPs to the drill site due to its proximity to the K-5 area.
31	Pads – Move drill site BT2 west away from Fish (Uvlutuuq) Creek	This has been included as an adaptive management BMP that would apply to all action alternatives: delay construction of drill site BT2 as long as possible to see if advances in extended reach drilling allow CPAI to reach target resources from a drill site located further away from Fish (Uvlutuuq) Creek
33	Processing facility – Relocate the Project processing facility closer to the GMT Unit boundary	This alternative concept has been incorporated into Alternative C: Disconnected Infield Roads.

Note: BLM (Bureau of Land Management); BMP (best management practice); BT1 (drill site BT1); BT2 (drill site BT2); BT4 (drill site BT4); CPAI (ConocoPhillips Alaska, Inc.); GMT (Greater Mooses Tooth); MTI (module transfer island)

3.1.5 Additional Alternatives Concepts Evaluated by ConocoPhillips Alaska, Inc.

CPAI conducted internal examinations of additional concepts to Project elements that were not further evaluated by the BLM or cooperating agencies as they had been sufficiently described and dismissed based on the CPAI's initial evaluation.

3.1.5.1 Use of the Clover Mine Site

The 19-acre Clover Mine Site was previously evaluated by BLM in the Alpine Satellite Development Plan (ASDP) Final EIS (BLM 2004) and the Greater Mooses Tooth 1 (GMT-1) Draft Supplemental EIS (BLM 2014) as a potential source of gravel that could supply approximately 626,000 cy of gravel, which is insufficient for the Project (which would require approximately 4.7 to 5.2 million cy of gravel).

CPAI further evaluated the Clover Mine Site as a potential Project mine site. Use of the Clover Mine Site was found to be disadvantageous over the proposed Project mine site located in the Tiŋmiaqsiuġvik area. Issues include the following:

- Proximity to Nuiqsut. The Clover Mine Site is approximately 1 mile closer to Nuiqsut and could result in increased impacts from blasting and other mine-site operations.
- Material quality. The gravel identified at the Clover Mine Site has more inter-bedded silt and other fine sediment than the material found in the Tiŋmiaqsiuġvik area. The poorer quality material would result in a larger footprint, relative to the proposed location for the same amount of gravel. This lower quality material would also result in increased maintenance of gravel infrastructure and increased potential impacts to adjacent waters or tundra due to the increased likelihood of material sloughing.
- Impacts to hydrology. The previously evaluated mine site contains an ephemeral drainage, and the larger site that would need to be developed to support the Project would impact several streams and drainages.
- Longer gravel hauling trips. The Clover Mine Site is farther from the Project and would result in longer round trips for haul trucks.

3.1.5.2 Ice Road or Tundra Access Only

Development of the Project with access to the Project area other than by gravel road or air was considered as a means of potentially reducing environmental effects from gravel extraction, establishment of gravel road or airstrips on top of tundra, and disturbance of wildlife through noise and movement. This alternative concept would not include construction of gravel roads, a gravel airstrip, or a gravel helipad; instead, access would be limited to use of low ground-pressure vehicles and ice roads.

This alternative concept was evaluated in the ASDP Final EIS (BLM 2004). Both the federal and state governments limit tundra travel, other than in emergencies, during large portions of the summer to prevent undue damage to the environment when the ground is soft. Regular routine maintenance and inspection trips to drill sites during summer by low ground-pressure vehicles would result in sustained and substantial damage to vegetation, soils, and water resources, including important wetland habitat. Vehicle crossings of rivers and streams would result in unacceptable damage to riparian resources and fish habitats and are prohibited in anadromous waterbodies, with few exceptions. Crossing Project area streams with low ground-pressure vehicles would not be feasible during some periods throughout the year because of breakup, freeze-up, or high-flow conditions. As a result, reliable access would be limited to winter when ice roads could be constructed and made available for transport to and from the Project area.

Limited access would create unacceptable hazards for safety and emergency response and limit the number of wells that could be drilled per season. Heavy equipment necessary for fire, rescue, and spill response, as well as critical medical equipment such as an ambulance, would not be capable of traveling cross-tundra or across wet environments. Although tundra-travel vehicles (e.g., low ground-pressure vehicles, tracked vehicles) may be permitted to travel cross-tundra during an emergency, they have serious limitations including a lack of integrated medical life support equipment, slow travel speeds, and limited weight and volume capacities. The ASDP Final EIS found that a project alternative that relies solely on low ground-pressure vehicles and ice roads for all but emergency access was not a reasonable alternative because it fails to provide adequate continuous access to achieve project purpose and need.

Because development with access other than gravel road or air would not provide continuous access to the Project area, it would not satisfy the project purpose and need to support production and transportation of petroleum resources from the Project area, while protecting important surface resources. Consequently, alternatives other than air or gravel access were not considered feasible and were not considered for further evaluation.

4.0 REASONABLE RANGE OF ALTERNATIVES

Four alternatives are analyzed in detail in the EIS:

- Alternative A: No Action
- Alternative B: Proponent's Project (Figure D.4.1)
- Alternative C: Disconnected Infield Roads (Figure D.4.2)
- Alternative D: Disconnected Access (Figure D.4.3)

Action alternatives (B, C, and D) presented in the EIS include variations on specific Project components (e.g., project access). The range of alternatives was developed to address the resource impact issues and conflicts identified during internal scoping with the BLM Interdisciplinary Team and external scoping with the public and cooperating agencies. Additionally, two options are presented for how sealift modules (required for all action alternatives) would be delivered to the Project, and any option could be paired with any action alternative:

- Option 1: Proponent's Module Transfer Island (Figure D.4.4)
- Option 2: Point Lonely Module Transfer Island (Figure D.4.5)

Sealift module delivery options are discussed in Section 4.7, *Sealift Module Delivery Options*.

4.1 Alternative A: No Action

Under the No Action Alternative, the Project would not be constructed, however, oil and gas exploration in the area would continue. Under the NPRPA, the BLM is required to conduct oil and gas leasing and development in the NPR-A (42 USC 6506a). On previously leased lands, the U.S. Court of Appeals has determined BLM has made an irrevocable commitment to allow some surface disturbances to support drilling and operations (BLM 2018). The No Action Alternative would not meet the Project's purpose and need and is included for detailed analysis to provide a baseline for the comparison of impacts of the action alternatives (BLM 2008, Section 6.6.2, *No Action Alternative*; 40 CFR 1502.14(d)).

4.2 Project Components Common to All Action Alternatives

Components common to all action alternatives are described below.

4.2.1 Project Facilities and Gravel Pads

The Project would include multiple gravel pads to support Project infrastructure, as described in the following sections. Pads would be a minimum of 5 feet thick to maintain a stable thermal regime and protect underlying permafrost with an average thickness (greater than 7 feet). Pad thickness and the gravel fill volume needed for each pad would vary due site-specific topography and design criteria (e.g., flat gravel surface). Embankment side slopes would be 2 horizontal to 1 vertical ratio (2:1). Erosion potential would be evaluated on a pad-specific basis and embankment erosion protection measures would be designed and employed as necessary.

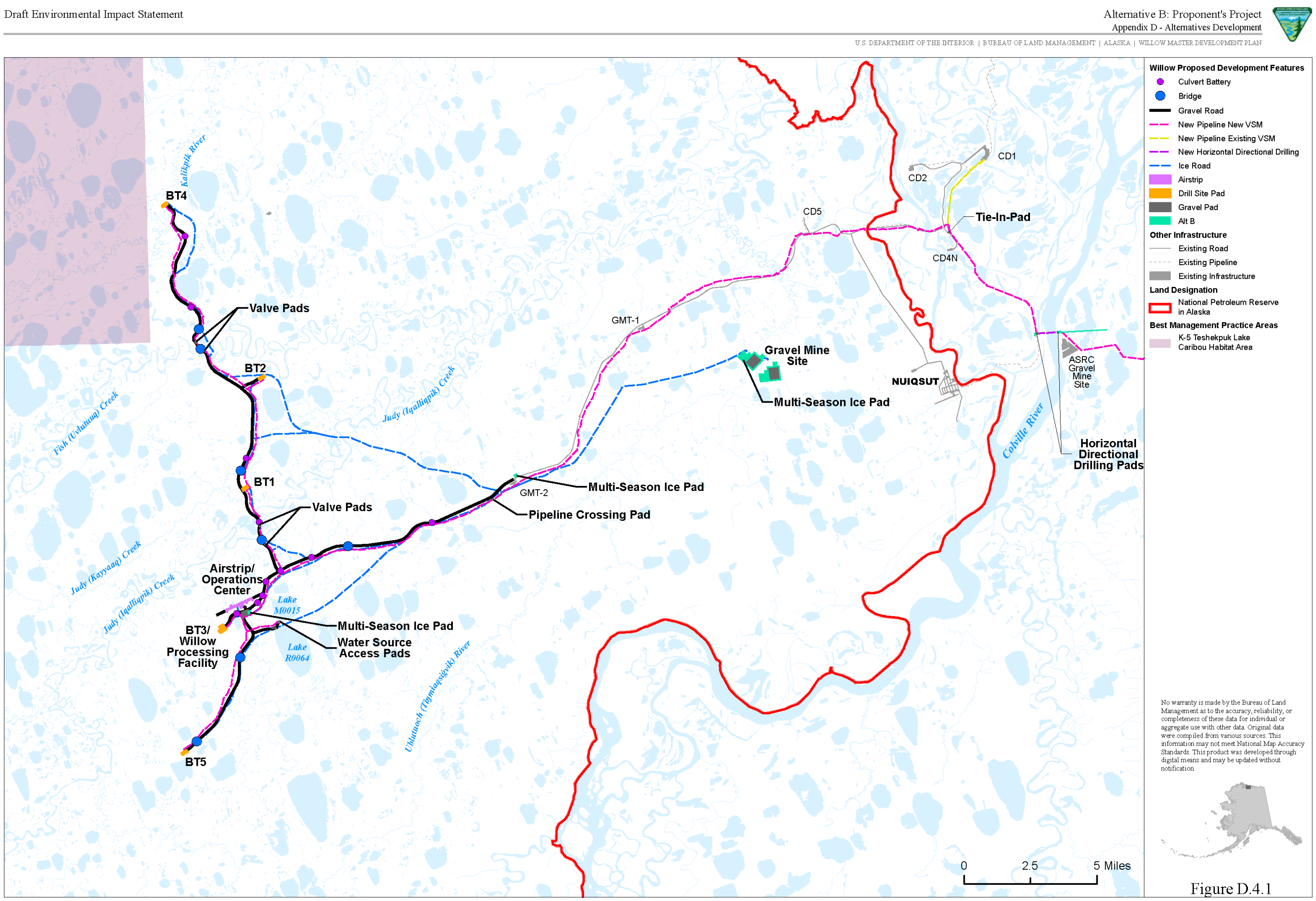

Figure D.4.1. Alternative B: Proponent's Project

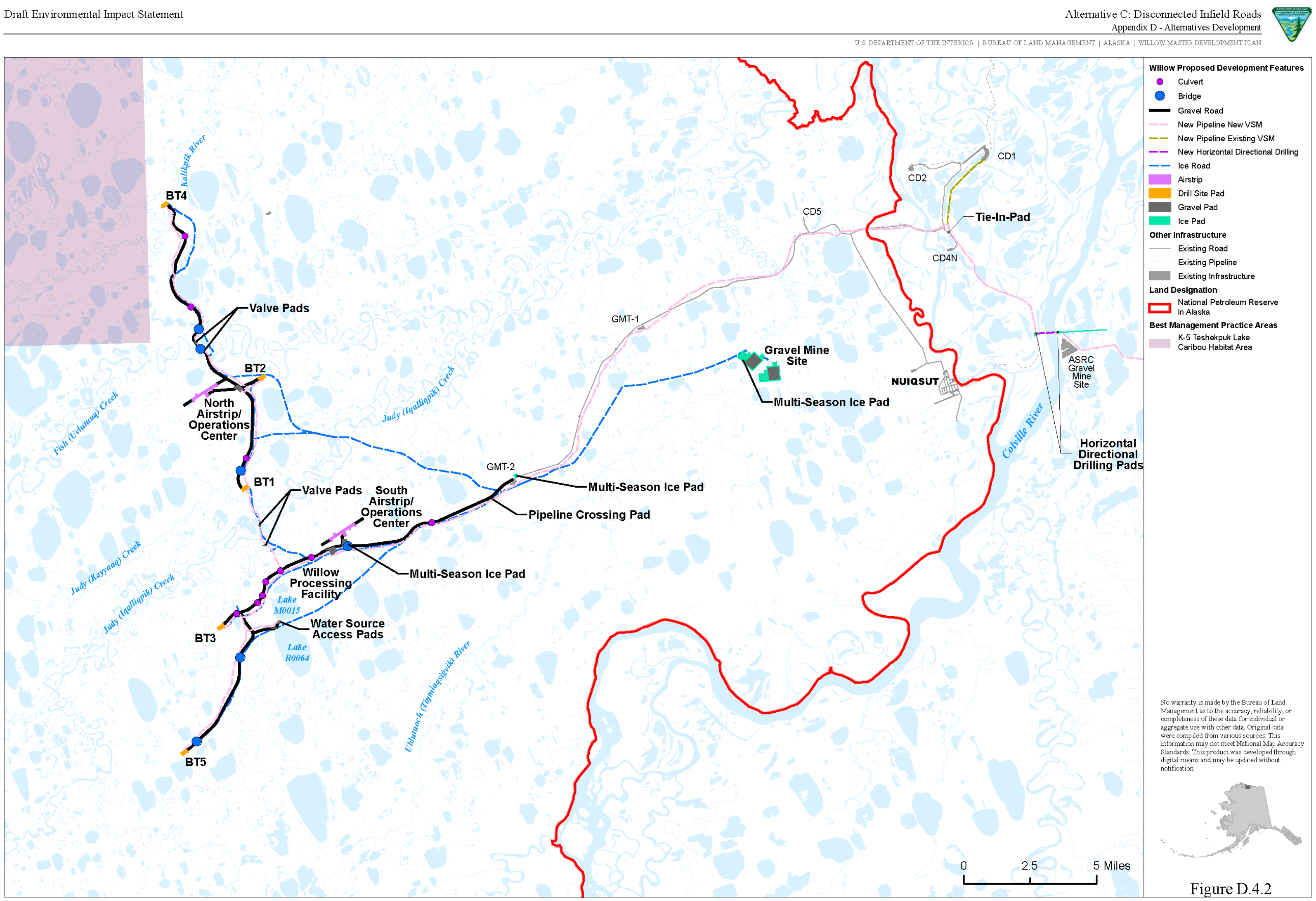

Figure D.4.2. Alternative C: Disconnected Infield Roads

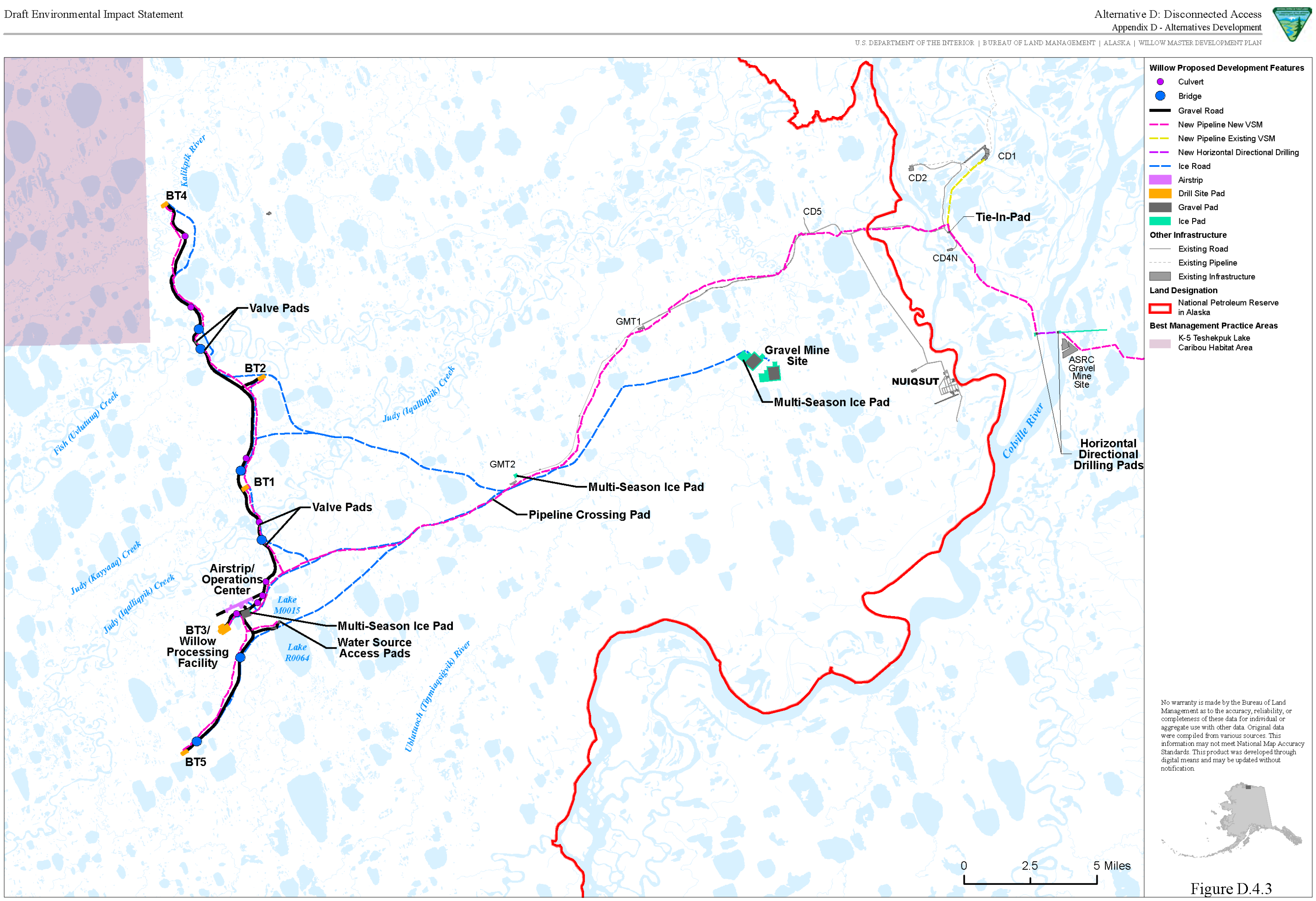

Figure D.4.3. Alternative D: Disconnected Access

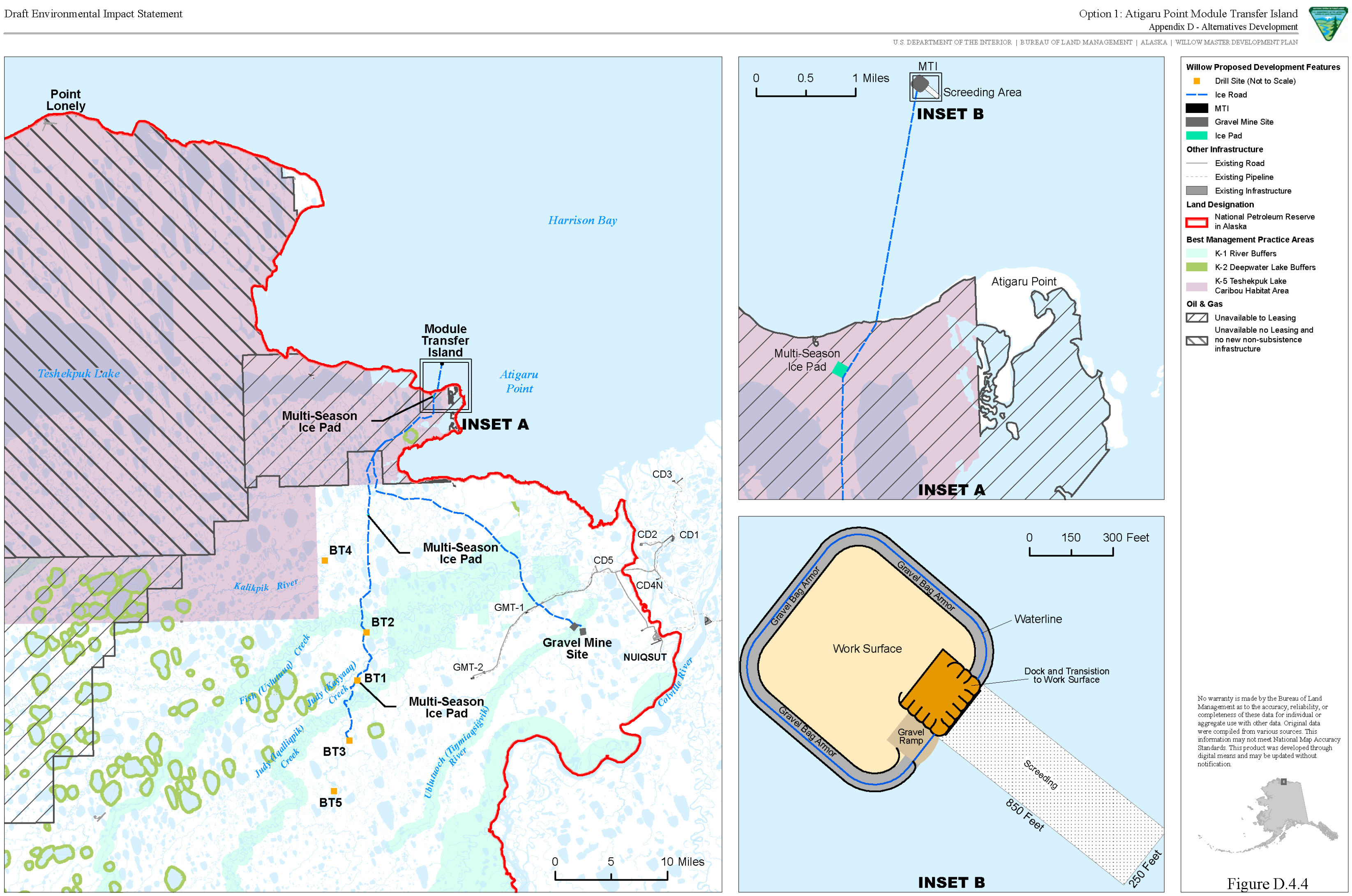

Figure D.4.4. Proponent's Module Transfer Island

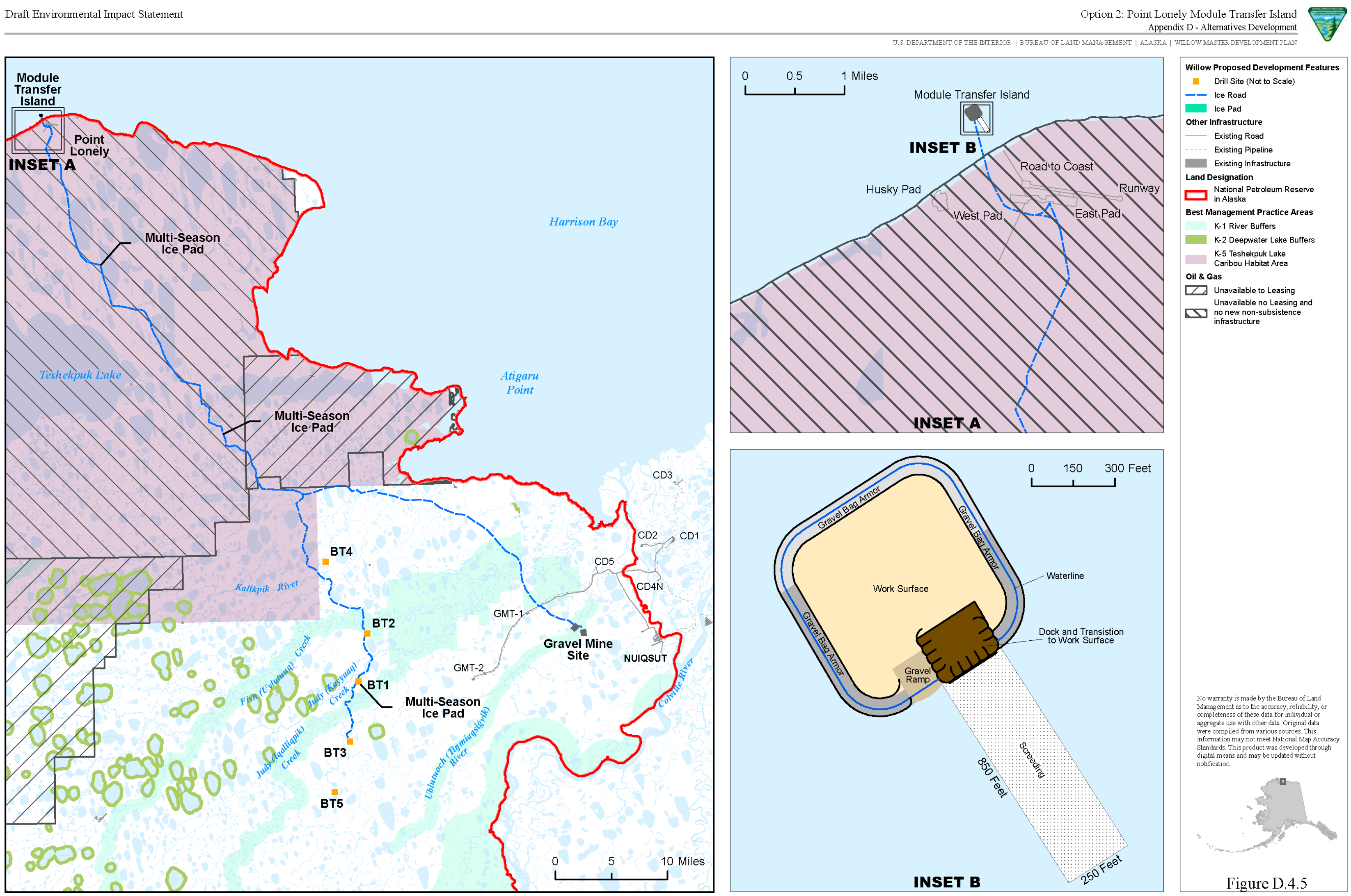

Figure D.4.5. Point Lonely Module Transfer Island

4.2.1.1 Willow Processing Facility
The Willow processing facility (WPF) would include the main plant facilities needed to separate and process multiphase production fluids and deliver sales-quality crude oil. Produced water would be processed at the WPF and re-injected to the subsurface as part of reservoir pressure maintenance/water flood for secondary recovery. Produced natural gas would be used to fuel plant and facility equipment, be re-injected into a producing reservoir formation to maintain reservoir pressure and increase recovery and used for **gas lift**. Under plant startups, shutdowns, and upset conditions, natural gas may be flared.

Processing equipment comprising the WPF would include:
- Emergency shutdown equipment
- Power generators
- Compressors
- Gas strippers
- Gas treatment facilities
- Heat exchangers
- Separators
- Stabilizer unit
- A flare system
- Oil-producing vessels
- Pumps
- Pigging facilities
- Metering facilities
- Electrical equipment
- Diesel fuel supply storage tank(s) and associated fueling station
- A tank farm, which could include methanol, sales oil or off-specification crude oil, crude oil flowback fluids, scale inhibitor, emulsion breaker, corrosion inhibitor, and minor volumes of other chemicals as required to support Project operations
- Warm storage facilities for equipment

At various times through the Project's producing lifetime, temporary modules, maintenance buildings, pipelines, and other structures may be used at the WPF to address short-term needs. Processing facility buildings would be designed to industry and building codes appropriate for each purpose. The designs would consider several factors, such as temperature, wind, precipitation, seismicity, building contents, purpose, personnel health and safety, and other environmental factors.

4.2.1.2 Drill Sites
The Project would construct five drill sites (all at the same location under each action alternative). Each drill site pad has been designed and sized to accommodate all drilling and operations facilities, wellhead shelters, drill rig movement, material storage, and well-work equipment. Each drill site would be sized to accommodate at least 50 wells at a 20-foot wellhead spacing. Additional facilities typical for drill sites would include:
- Emergency shutdown equipment
- Fuel gas treatment equipment
- Well test and associated measurement facilities
- Electrical and instrumentation control equipment
- Pig launchers and receivers
- Chemical injection facilities (including tanks within modules, containment, and exterior tank fill connections)
- Production heater and associated equipment
- Spill response equipment containers
- Communications infrastructure (including tower(s) up to 195 feet tall)
- High-mast lights

- Temporary tanks to support drilling and well work operations
- Production operations storage tanks
- Production operations stand-by tank (normally empty)
- Transformer platforms (oil-insulated)
- Low-pressure and high-pressure pipe racks or manifold piping (or both)

Project wells would use **hydraulic fracturing** and **extended reach drilling** to access the targeted hydrocarbon deposits and develop wells (Section 4.2.10.2.1, *Hydraulic Fracturing*). Hydraulic fracturing is a well stimulation technique that would increase the flow of oil and natural gas. Extended reach drilling is a directional drilling technique used to develop long, horizontal wells and allow a larger area to be reached from a single surface location (i.e., drill site pad), providing greater access to a reservoir.

Wells would be categorized as either production or injection. The production wells would generate the Project's oil and gas production while the injector wells would be used to inject water (i.e., treated seawater and/or WPF –processed produced water) and/or gas into the producing formation(s) to maintain reservoir pressure. Wells would be equipped with appropriate well safety valve systems in accordance with 20 AAC 25.265. Manifold or pipe rack piping (or both) would combine individual wellhead piping into a common gathering line through which all produced fluids would be transported to the WPF.

4.2.1.3 Willow Operations Center

The base of operations for the Project would be the Willow Operations Center (WOC) which would be located near the WPF (but separated by approximately 1 mile for safety). The WOC location would minimize risk to Project personnel by placing living quarters away from potential blast hazards associated with the WPF, which is consistent with current best safety practices and standards, including the American Petroleum Institute (API) Recommended Practice (RP)-752. The WOC would be adjacent to the Project airstrip.

The WOC would contain utility buildings and storage facilities to support operations, including:

- Permanent Willow Operations Camp facilities including living quarters, offices, dining facilities, medical clinic, wellness center, and camp maintenance facilities
- Wastewater and water treatment plants, lab, and chemical storage
- Freshwater pipeline and water tanks
- Class I underground injection control (UIC) disposal well(s)
- Emergency response center
- Emergency backup generators
- Spill response shop
- Craft maintenance shop and tool room
- Hazardous waste accumulation and storage
- Fleet maintenance shop
- Fabrication shop
- Warehouse
- Cold storage tent
- Communications infrastructure, including a communications tower between 60 and 200 feet tall
- Drilling shop and mud plant
- Municipal solid waste incinerator
- Helipad, helicopter storage tent, and jet fuel tank and pump house
- Staging areas
- Office and craft maintenance shops to provide equipment repair, fabrication, and maintenance support

In addition to the permanent surface structures, structures such as camps, offices, shops, envirovacs, connexes, fuel and chemical storage areas, and warehouses may be used at the WOC to support specific Project activities.

Alternative C would include a second WOC (North WOC) which would have similar infrastructure described above, including a Class I UIC disposal well(s).

4.2.1.4 Valve Pads
Isolation valves would be installed on each side of pipeline crossings at Fish (Uvlutuuq) Creek and Judy (Iqalliqpik) Creek, allowing isolation of produced fluids pipelines on either side of the bridges to minimize potential spill impacts in the event of a leak or break. To support valve infrastructure, gravel pads would be constructed on each side of the identified crossings (two valve pads per crossing). Valve pads would be located adjacent to gravel roads (except at Judy [Iqalliqpik] Creek under Alternative C where there would be no road at this crossing) and approximately 400 to 2,000 feet from the creeks.

4.2.1.5 Pipeline Pads
Four pipeline pads would be constructed to support pipeline construction and operations:

- One pipeline crossing pad would be located along the import/export pipelines near GMT-2 to allow north-to-south ice road crossings. Pipelines would be placed in casings through the gravel pad embankment.
- Two new horizontal directional drilling (HDD) pipeline pads would be constructed adjacent to the existing Alpine Sales Pipeline HDD Colville River crossing. These pads would be where the proposed diesel and seawater pipelines (Section 4.2.2.3, *Other Import/Export Pipelines*) transition from aboveground to below ground on each side of the river. These gravel pads would include a rectifier (west bank) to support the cathodic protection system (i.e., corrosion prevention equipment) and thermosyphons (east and west banks).
- The Willow Pipeline (Section 4.2.2.2, *Willow Pipeline*) would tie into existing pipeline infrastructure at a new tie-in pad located along the Alpine Sales Pipeline near Alpine CD4N.

4.2.1.6 Water Source Access Pads
Two water source access pads would be used to provide access to the freshwater intake infrastructure at Lakes M0015 and R0064. The pads would be sized to minimize the gravel footprint while maintaining adequate space for vehicles to access the water sources and safely maneuver. The water source access pads would be connected to Project via a water source access road connected to the road leading to Bear Tooth drill site BT5 (BT5).

4.2.2 Pipelines
The Project would include infield and import/export pipelines. Infield pipelines would carry a variety of products, including produced fluids, produced water, seawater, miscible injectant, and gas, between the WPF and each drill site.

Import/export pipelines would include the Willow Pipeline, a seawater pipeline, and a diesel pipeline. The Willow Pipeline, a U.S. Department of Transportation (USDOT) regulated sales-oil transport pipeline, would carry sales-quality crude oil from the WPF to a tie-in with the Alpine Sales Pipeline near Alpine CD4N. The seawater pipeline would import seawater from the existing Seawater Treatment Plant in Kuparuk to the Project area. The diesel pipeline (a USDOT-regulated pipeline) would transport miscellaneous refined hydrocarbon products from the Kuparuk River Unit (Kuparuk) CPF2 to the Alpine processing facility at Alpine CD1 for Alternative B and to the WOC for Alternatives C and D. A freshwater pipeline would transport freshwater from the primary freshwater sources at Lakes M0015 and R0064 to the WOC.

Pipeline design would conform to the American Society of Mechanical Engineers codes B31.4 and B31.8, as appropriate, applicable federal and state standards, and CPAI’s internal specifications and criteria. All pipelines would be hydrostatically tested prior to startup as required by the appropriate design code (e.g., B31.4 and B31.8). Typical pipeline construction would consist of carbon steel pipe as dictated by service, pipeline size, and code; pipelines would be externally coated with fusion-bonded epoxy to prevent external corrosion and then covered with rigid polyurethane insulation and metal jacketing that would be non-reflective or buffed in the field. Pipelines would rest on common horizontal support members (HSMs) atop vertical support members (VSMs) placed approximately 55 feet apart. VSMs would have a typical diameter of 12 to 18 inches and disturbance footprint of 18 to 24 inches (up to 3.1 square feet). VSMs would be driven to a minimum of 17 feet below the active permafrost layer to prevent subsidence or frost jacking. CPAI would maintain VSMs through its asset integrity inspection and maintenance program for monitoring and repairs.

At Fish (Uvlutuuq) Creek, Willow Creek 4, and Judy (Iqalliqpik) Creek (except under Alternative C), pipelines would be placed on structural steel supports attached to the bridge girders, below the bridge deck. At smaller stream crossings, pipelines would be installed approximately perpendicular to the channel with VSMs on each side of the crossing to avoid VSM placement in streams to the extent practicable. VSMs placed below ordinary high water (OHW) would typically be 24-inches in diameter. Fiber-optic and power cables would be suspended via messenger cable attached to the HSMs. Pipelines (including suspended cables) on new VSMs would be a minimum of 7 feet above the surrounding ground surface, including in areas where new VSMs would be placed adjacent to existing Alpine pipelines, which may be less than 7 feet above the ground surface. New pipelines that share existing VSMs and HSMs would match the existing HSM heights. Where Project pipelines would parallel existing pipelines, the new VSMs would be aligned with the existing VSMs (to the extent practicable) to avoid a “picket fence” effect. Except for locations where there is no gravel road connecting Project facilities, all pipelines would parallel new and existing gravel roads, typically between 500 and 1,000 feet from roadways. This separation distance provides daily opportunities to observe pipelines for leaks or other damage, while maintaining enough distance to prevent collisions between pipelines and vehicles and reduces impacts (e.g., disturbance) for caribou crossing roads and pipelines.

4.2.2.1 Infield Pipelines

Infield pipelines would include the following pipelines connecting the WPF to each drill site:

- Produced fluids pipeline – Produced crude oil, gas, and water from each drill site to the WPF for processing.
- Injection water pipeline – Seawater or produced water transported from the WPF for injection to support enhanced oil recovery.
- Gas pipeline – Lean gas transported from the WPF for artificial lift, pressure support, and fuel gas.
- Miscible-injectant pipeline – Miscible injectant transported from the WPF for injection to support enhanced oil recovery.

The infield pipeline supports between the WPF and BT1, and between BT2 and BT4, would include space to accommodate future pipelines (two pipelines and one pipeline, respectively) to support potential future development in the Project area (e.g., Greater Willow 1 [GW1] and GW2 [Figure D.1.1]).

All infield pipelines would be designed to allow pipeline inspection and maintenance (e.g., pigging) between each drill site and the WPF. Permanent pigging facilities would be installed for the produced fluid and injection water pipelines. Pipeline valves that can be closed in the event of an emergency would be installed on produced fluids pipelines at each side of the Judy (Iqalliqpik) Creek and Fish (Uvlutuuq) Creek crossings, isolating the section of pipeline between the valves to minimize potential spill impacts in the event of a pipeline leak or break.

Pipelines would be designed to minimize redundant parallel pipelines to the extent practicable. For example, infield pipelines from Bear Tooth drill site BT4 (BT4) would tie in to Bear Tooth drill site BT2 (BT2) infield pipelines at BT2, and BT2 pipelines would tie in to Bear Tooth drill site BT1 (BT1) pipelines to reach the WPF. An additional set of infield pipelines would connect BT5 to the WPF; under Alternative C, an additional set of infield pipelines would connect BT3 to the WPF. Infield pipelines would use single VSMs, except where anchor supports are used in expansion loops (i.e., “Z bends”), where two VSMs per pipeline support would be used.

4.2.2.2 Willow Pipeline

The Willow Pipeline, a USDOT-regulated sales oil transport pipeline, would carry sales-quality crude oil processed at the WPF to a tie-in with the existing Alpine Sales Pipeline at tie-in pad near Alpine CD4N. From Alpine CD4N, sales-quality oil would be transported via the existing Alpine Sales Pipeline to the Kuparuk Pipeline and onward to the Trans-Alaska Pipeline System (TAPS) near Deadhorse, Alaska, for shipment to market. The Willow Pipeline would be placed on new VSMs between the WPF and the tie-in pad near Alpine CD4N. Between the WPF and the tie-in pad near CD4N, vertical lops or isolation valves would be installed on each side of the Ublutuoch (Tiŋmiaqsiuġvik) River, and on each side of the segments crossing the Nigliagvik Channel, Nigliq Channel, and Lakes L9341 and L9323.

The Willow Pipeline would comply with USDOT Spill Response Plan requirements.

4.2.2.3 Other Import/Export Pipelines

Other import/export pipelines would include a seawater import pipeline, a diesel import pipeline, and a freshwater pipeline. The new seawater pipeline would import seawater from Kuparuk CPF2 to the WPF for injection in the target reservoirs. The USDOT-regulated diesel pipeline would transport diesel fuel and other refined hydrocarbon products to power drilling support equipment, well work operations, and vehicles and equipment, as well as provide freeze protection of wells.

Under Alternative B, the diesel pipeline would extend from Kuparuk CPF2 to the Alpine processing facility at Alpine pad CD1; from the Alpine processing facility, diesel fuel would be trucked to the WPF and other locations in the Project area, as needed. Under Alternatives C and D, the diesel pipeline would transport fuel from Kuparuk CPF2 to the WOC (South and North WOCs for Alternative C). The seawater and diesel pipelines would be placed on new VSMs from Kuparuk CPF2 to the WPF and Alpine CD4N, respectively. These VSMs would be shared with the Willow Pipeline where available. The diesel pipeline would be installed on an existing pipe rack between Alpine CD4N and the Alpine processing facility.

The seawater and diesel pipelines would cross beneath the Colville River and would be installed using HDD. The Colville River crossing would be located adjacent to the existing Alpine Pipeline HDD crossing. Each pipeline would be installed approximately 60 feet apart. Pipelines would be insulated and placed within an outer pipeline casing, which would serve to inhibit heat transfer to permafrost, contain fluids in the event of a leak or spill, and provide structural integrity.

The HDD process would involve drilling a borehole under the Colville River that is large enough to accommodate the pipeline casing. The HDD entry and exit locations would be set back more than 300 feet from the riverbanks, and the total length of the borehole would be approximately 4,300 feet. The depth below the river channel bottom at the center of the HDD crossing would be approximately 70 feet. Throughout the process of drilling and enlarging the borehole, a slurry made of naturally occurring nontoxic materials (typically bentonite clay and water) would be circulated through the drilling tools to lubricate the drill bit, remove drill cuttings, and hold the borehole open. Pipelines sections would be staged and welded together to form segments long enough to span the entire crossing. Once the borehole is ready, the completed pipeline segments would be pulled through the drilled bore hole.

Two new gravel pads would be constructed for the HDD crossing where the pipelines transition from aboveground to belowground on either side of the river adjacent to the existing Alpine Pipeline HDD gravel pads. The HDD crossing would be constructed during winter. Two HDD ice pads and an HDD laydown pad (approximately 42 total acres) would be constructed on each side of the Colville River to support the HDD crossing construction.

The freshwater pipeline would transport water from the primary freshwater sources (Lakes M0015 and R0064) to the WOC (South WOC under Alternative C, which would also include a freshwater pipeline connection to the North WOC; Section 4.2.4.5, *Potable Water*).

4.2.3 Access to the Project Area

Access to the Project area from Alpine, Kuparuk, or Deadhorse would occur via ground transportation over gravel and ice roads, as well as fixed-wing aircraft and helicopters. The sealift modules comprising the processing facilities at the WPF and the drill sites would be delivered to the North Slope by sealift barge. Barge offloading is proposed at either Point Lonely or Atigaru Point on a constructed gravel island. Sealift modules would be staged on the island during the open-water season and then transported to the Project area via ice road the following winter. Anticipated ground, air, and marine traffic is detailed by alternative (Section 4.3, *Alternative B: Proponent's Project*; Section 4.4, *Alternative C: Disconnected Infield Roads*; and Section 4.5 *Alternative D: Disconnected Access*).

4.2.3.1 Ice Roads

Ice roads would be used primarily during construction to support gravel infrastructure and pipeline construction, for lake access, and to access the selected gravel source(s). Due to heavy equipment size and frequency of construction traffic, safety considerations dictate the use of separate ice roads for pipeline construction, gravel placement, and general traffic.

Ice road construction is dependent upon ground temperature and precipitation (i.e., sufficient snow for pre-packing routes) and typically begins in November or December. Vehicle access via ice road depends on the opening and closing dates of the ice road season and the distance from existing infrastructure. The usable ice road season for travel to the Project area is anticipated to be shorter than that of Kuparuk and Alpine operations due to the logistical challenges of constructing and completing a remote ice road. Based on experience at GMT-1 and other exploration projects conducted in the NPR-A, the annual ice road use season for the Project is expected to be 90 days, from approximately January 25 through April 25. A typical ice road would be 8 inches thick with a 35-foot-wide surface. A typical ice road used for gravel hauling would have a 70-foot-wide surface. All ice-road routes in the EIS are estimated and final alignments would be determined through design optimization and impact minimization analysis prior to Project construction.

Ice road design begins with a desktop analysis to identify preliminary routes that have been field verified the prior summer and adjusted to address design constraints and field conditions. Routes would be field staked in October and November, and ice road construction would begin when suitable conditions allow. Ice road construction would begin by prepacking the route with tundra approved vehicles, after which general construction would commence. Typical equipment used in ice road construction includes Tuckers, Rolligons, water buffalos, terra gators, front-end loaders, maxi hauls, water trucks, and graders. Following the construction of ice roads, water trucks, graders, and snow blowers are used for ice road maintenance. Ice and snow ramps, thicker ice sections at select water crossings, and use of supplemental materials such as rig mats, may be used to increase ice road strength.

Following the end of the ice road season, all ice road stream crossings would be breached or slotted, and ice built up artificially at crossings (e.g., ice or snow ramps) would be removed to match the static water elevation. Following spring breakup, work crews would conduct "stick picking" to remove any debris or anthropogenic materials.

BMPs typically used in conjunction with ice roads include:

- Placement of delineators to mark ice road edges
- Frequent maintenance of routes
- Use of portable spill containment (i.e., duck ponds) under vehicles and equipment
- Coordination with the Kuukpik Subsistence Oversight Panel and the Ice Road Monitors to patrol routes for spill cleanup needs
- Summer cleanup activities (i.e., "stick picking")

Large modules comprising the processing facilities would be delivered to the either Point Lonely or Atigaru Point by sealift barge (Section 4.7, *Sealift Module Delivery Options*) during the open-water season. During the following winter construction season, the sealift modules would be transported via ice road (combination of sea ice and over tundra) to the Project area. A typical tundra-based ice road used for sealift module mobilization would have a 70-foot-wide surface and be paralleled by a 35-foot-wide surface ice road for support vehicle traffic.

During drilling and operations, seasonal ground access from Deadhorse and Kuparuk to the Project area would be provided by the annually constructed Alpine Resupply Ice Road and then via existing Alpine and GMT gravel roads; under Alternative D, an annual ice road would be constructed from GMT-2 to the Project area. Alternative C would require the construction of an annual ice road between the WPF and BT1 to provide annual resupply for drill sites BT1, BT2, and BT4. For annual (i.e., resupply) ice roads, the same general area would be used year after year, with the previous year's location being mapped so subsequent years can follow the same route as is reasonably practicable and appropriate. This method of ice road layout is the least impacting from an overall footprint perspective. CPAI would remove any anthropogenic debris (i.e., "stickpick") from the route annually and perform annual inspections as required by respective landowners and land managers.

Estimated ice road mileage by alternative is summarized in Table D.4.1.

Table D.4.1. Estimated Total Ice Road Mileage by Alternative

Year	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access
2021	69.7	61.3	90.4
2022	76.2	77.4	96.9
2023	68.5	60.0	65.1
2024	76.1	95.8	71.6
2025	37.1	8.5	21.7
2026	37.4	30.7	15.0
2027	7.1	42.6	42.2
2028	0.0	8.9	49.3
2029	0.0	3.9	17.1
2030	0.0	3.9	9.8
2031+	0.0	3.9	9.8
2031 – Life of Project[a]	0.0	78.0[b]	215.6[c]
Total	372.0	471.0	694.5

Note: + (indicates annual use from 2031 to end of the life of the Project in 2050 for Alternatives B and C and 2052 for Alternative D). All mileages are approximate and are based on gravel road alignments.
[a] Life of Project would be 30 years (2021 through 2050) for Alternatives B and C, and 32 years (2021 through 2052) for Alternative D.
[b] Assumes 3.9-mile-long annual ice road to reach drill site BT2 for the life of the Project.
[c] Assumes 9.8-mile-long annual ice road between Greater Mooses Tooth Unit and the Project area for the life of the Project.

4.2.3.2 Gravel Roads

All-season gravel roads would connect the Project drill sites to the WPF and to the existing Greater Mooses Tooth (GMT) Unit (with some exceptions under Alternatives C and D) and Alpine gravel infrastructure. Gravel roads would be designed to maintain the existing thermal regime and would be a minimum of 5 feet thick (average of 7 feet thick due to topography) and have 2:1 side slopes. Roads accessing the airstrip(s) and drill sites would be 32 feet wide at the driving surface to allow for drill rig movement, with an average toe-to-toe width of approximately 61 feet. The water source access road would be 24 feet wide at the surface with an average toe-to-toe width of approximately 52 feet. The airstrip lighting access and secondary access roads would be 18 feet wide at the surface and have an average toe-to-toe width of approximately 46 feet. Roads would include subsistence tundra access ramps at road pullouts; locations and designs would be based on lessons learned from GMT-1 and GMT-2, on community input, and in consultation with Nuiqsut, but would generally be every 2.5 to 3 miles. These pullouts and tundra access ramps would allow local residents to access the area for subsistence use.

Where practicable, roads would be constructed at least 500 feet from pipelines to minimize caribou disturbance, prevent excessive snow accumulation from snowdrifts, and allow for snow removal.

However, pipelines would typically be constructed within 1,000 feet of roads to allow visual inspection from the road. Where practicable, roads would be designed to conform to BLM requirements and BMPs. Anticipated deviations from these BMPs are detailed by alternative (Section 4.3, *Alternative B: Proponent's Project*; Section 4.4, *Alternative C: Disconnected Infield Roads*; and Section 4.5, *Alternative D: Disconnected Access*).

4.2.3.2.1 Bridges

All action alternatives would include bridges. All bridges would be designed to maintain bottom chord clearance of at least 4 feet above the 100-year design-flood elevation or at least 3 feet above the highest documented flood elevation, whichever is higher. Water surface elevations would be analyzed considering snow and ice impacts, as well as open water conditions. Design analysis would be based on observations and measurements and modeled conditions (e.g., ice and snow effects), and would vary from crossing to crossing based on site-specific conditions.

Shorter, single-span bridges would be designed to avoid placement of piers in main channels, where practicable. Each bridge deck would have a removable guardrail and would be designed to support drill rig movement. At the Fish (Uvlutuuq) Creek, Willow Creek 4, and (excluding Alternative C) Judy (Iqalliqpik) Creek crossings, pipelines would be placed on structural steel supports attached to the bridge girders below the bridge deck. At smaller streams, pipelines would cross on VSMs spanning the stream crossing.

The multi-span Judy (Iqalliqpik) Creek, Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 2, and Willow Creek 4 bridges would be constructed on steel-pile pier groups positioned approximately 60 feet apart. Crossings over Willow Creek 4A and Willow Creek 8 would be constructed using single-span bridges (sets of four pilings positioned approximately 60 feet apart with sheet-pile abutments for erosion protection at each end of the bridge). Bridged crossings would range from 40 to 500 feet in length. Specific bridge crossings are detailed in Section 4.3, *Alternative B: Proponent's Project*; Section 4.4, *Alternative C: Disconnected Infield Roads*; and Section 4.5, *Alternative D: Disconnected Access*.

4.2.3.2.2 Culverts

Culverts would be designed, constructed, and maintained to ensure fish passage and stream flow. Culverts would be placed in the road to maintain natural surface drainage patterns; culverts at stream or swale crossings would be placed perpendicular to the road, where feasible. The size, layout, and quantity of culverts crossing streams or swales would be based on site-specific conditions in order to pass the 50-year flood event with a headwater elevation not exceeding the top of the culvert (headwater/diameter ratio of 1 or less). Typical culverts within the **culvert battery** would be steel pipe pile. Culverts would extend approximately 2 feet past the toe of the slope, have a minimum of 3 feet of gravel cover (dependent on pipe material, wall size, and design loads), and have a minimum of 3 feet of spacing between the outer walls of each culvert to provide for proper gravel compaction and load distribution.

Stream crossings where fish passage is required (as designated by the Alaska Department of Fish and Game [ADF&G]) would be designed with at least one of the culverts in the battery having the invert embedded 20% below grade, situated in the deepest part of the stream channel. Fish passage culverts would be backfilled to match existing grade (20% of culvert diameter) to provide conditions similar to a stream bed within the culvert. Fish passage culverts would be corrugated steel plate or steel pipe pile. Baffles may be added on a site-specific basis and in consultation with permitting agencies.

Preliminary cross-drainage culvert locations would be selected based on aerial photography. CPAI (or its representative) would walk the road alignment prior to construction to optimize final culvert locations, noting low areas where culverts are needed, and review the data with regulatory agencies for concurrence. Thus, the final design for the size, number, and location of the cross-drainage culverts would be determined following the field survey. The estimated spacing of the cross-drainage culverts is one every 1,000 feet; however, some culverts may be spaced closer or farther than the 1,000-foot estimate, as is common for roads associated with North Slope oil and gas development. The culverts would be installed per the final design prior to breakup of the first construction season, but additional culverts may be placed after breakup as site-specific conditions are further assessed with regulatory agencies. Culverts would be regularly inspected as part of CPAI's roads and pads maintenance program.

4.2.3.3 Airstrip and Associated Facilities

Year-round access to the Project area from Alpine, Kuparuk, Deadhorse, or other locations would be provided by aircraft. Air access would be supported by a 5,600-foot-long gravel airstrip with aprons located near the WOC under Alternatives B and D and near the South WOC under Alternative C; Alternative C would include a second airstrip near the North WOC (Section 4.2.3, *Access to the Project Area*). The airstrip(s) would be capable of supporting and could include regular use by Hercules C-130, DC-6, Otter, and CASA aircraft, or similar. Additional airstrip facilities would include a traffic control tower and runway lights. Helicopters would be used to support Project construction, ongoing environmental studies, ice road permit compliance, and to a lesser extent, drilling and operations. Helicopter support for future exploration, including exploration wellhead inspections and debris cleanup (i.e., "stick picking") from winter exploration activities, is not part of the Project, but it is described within the context of cumulative effects (Willow MDP EIS, Section 3.19, *Cumulative Effects*).

The location of the airstrip(s) is constrained by a number of factors to ensure the safety of aircraft taking off and landing at the airstrip. These factors include the height of the drill rig(s) at BT3, the WPF and WOC structure heights, and the setback distances required by the Federal Aviation Administration for aircraft approaches and takeoffs. The airstrip(s) would be oriented in a southwest-northeast direction due to the prevailing winds. Airstrip locations and access roads vary by alternative.

Aircraft would support the transportation of work crews, materials, equipment, and waste to and from the Project area and Fairbanks, Anchorage, Kuparuk, and Deadhorse. Air transportation to the Project area would occur year-round. During the winter ice-road season (approximately January 25 through April 25), material resupply and waste transportation to Kuparuk and North Slope gravel road system would also occur via the annual Alpine Resupply Ice Road. Aircraft would maintain altitudes consistent with BMP F-1, except during takeoffs and landings and unless doing so would endanger human life or violate safe flying practices. Aircraft flight paths would be routed north of Nuiqsut to the extent practicable.

4.2.4 Other Infrastructure and Utilities

4.2.4.1 Ice Pads

Seasonal ice pads and multi-season ice pads would be used to support construction. Single-season ice pads, ice pads built and used for a single winter construction season, would be used during all years of construction to house construction camps, stage construction equipment, and support construction activities. Single-season ice pads would be used during construction at the gravel mine site during gravel mining activities (Section 4.2.6, *Gravel Mine Site*), on either side of bridge crossings during gravel road and pipeline construction, at the Colville River HDD pipeline crossing, and at other locations as needed near proposed infrastructure within the Project area.

In addition to single-season ice pads, multi-season ice pads would be used on a limited basis to stage construction materials between winter construction seasons with the goal of avoiding permanent fill for temporary activities. Multi-season ice pads would be constructed similarly to single-season ice pads with compacted snow over a base layer of ice. However, multi-season ice pads would also include a vapor barrier over the ice to prevent melting from rain and evaporation, as well as foam insulation mats to insulate the pads, and white tarps to reflect sunlight and heat. The multi-season ice pads would then be covered by rig mats made of wood, steel, or composite materials (USACE 2012, Appendix G). Once a multi-season ice pad has served its purpose, the rig mats, tarp, insulation, and vapor barrier would be removed, any spills or releases would be cleaned, and the ice base would be allowed to melt over the course of the summer.

Three 10.0-acre multi-season ice pads would be used during Project construction under all action alternatives. These include multi-season ice pads near GMT-2, near the WOC (South WOC under

Alternative C), and at the Tiŋmiaqsiuġvik Mine Site. Construction and use of these three pads would allow ice road, gravel mining, and other construction equipment to be stored in the field over the summer to support earlier construction starting during the following winter construction season, while minimizing the need for additional gravel infrastructure.

4.2.4.2 Camps

Camps required to support Project construction include camps within the Project area at the WOC (for Alternatives B and D; at the North and South WOCs under Alternative C) and near the Proponent's MTI or Point Lonely MTI, as well as other existing camp space at Alpine (Alpine Operations Camp), the Kuukpik Pad (near the intersection of the Nuiqsut Spur Road and Alpine CD5), and the Sharktooth Camp in Kuparuk. Housing of construction workers at the Kuukpik Hotel in Nuiqsut would also be possible. Camps to support drilling would be located at each drill site. The Willow Camp would support operations and would be housed on the WOC pad (for Alternatives B and D; at the North and South WOCs under alternative C). Details of camp sizes and locations by alternative are provided in Section 4.3, *Alternative B: Proponent's Project*; Section 4.4, *Alternative C: Disconnected Infield Roads*; Section 4.5 *Alternative D: Disconnected Access*, and Section 4.7, *Sealift Module Delivery Options*.

4.2.4.3 Power Generation and Distribution

Electrical power for the Project would be generated by a 98-megawatt power plant at the WPF, equipped with natural gas-fired turbines. Power would be delivered to each drill site and the WOC(s) via power cables suspended from pipeline VSMs using messenger cables attached to the HSMs. Following facility startup, the power plant at the WPF would also be used to power drill rigs, except during periods when power from the WPF is unreliable.

During construction and drilling, prior to completion of the permanent power supply, portable generators would provide temporary power at the various locations. The portable generators would be fueled by ultra-low-sulfur diesel. Once fuel gas is available, upon startup of the WPF, diesel-fired emergency backup generators would be installed at the WPF and at the Willow Camp (located on the WOC pad). Portable diesel-fired emergency backup generators would be available to provide emergency power at drill sites. Permanent electric power generator sets would be totally enclosed or acoustically packaged to reduce noise emissions.

4.2.4.4 Communications

Communications infrastructure throughout the Project area would be provided by fiber-optic cables suspended from pipeline VSMs via messenger cable attached to HSMs. Communication towers would be located at the WPF and at each drill site. The communication towers would range between 60 and 195 feet tall. Permanent towers would be triangular, self-supporting lattice towers and would not use guy wires. Temporary towers would be pile supported and may require guy wire supports. Guy wires would include devices to mitigate bird strikes (e.g., bird diverters). All towers would have warning lights to meet Federal Aviation Administration regulations. Bird nesting diversion tactics (e.g., spikes) may be installed on towers, as is practicable given the equipment layout and potential for snow and ice loading and associated concerns.

4.2.4.5 Potable Water

Lakes M0015 (also called R0056) and R0064 (Figures D.4.1, D.4.2, and D.4.3) would be the primary sources of freshwater for domestic use under all action alternatives. Lake M0015 has an estimated total lake volume of 643 million gallons (MG) and a maximum recommended winter-withdrawal volume of 8.9 MG. Lake R0064 has an estimated total lake volume of 1,570 MG and a maximum recommended winter-withdrawal volume of 11.4 MG.

The freshwater intake infrastructure would include a submerged pump (screened per ADF&G design requirements) with a 10- by 12-foot pump house set on piles at both lakes. The freshwater intake infrastructure would be accessed by a water source access road and pads (Section 4.2.1.6, *Water Source*

Access Pads, and Section 4.2.3, *Access to the Project Area*). A pipeline would transport freshwater from the intake infrastructure directly to the water treatment plant located on the WOC pad (South WOC under Alternative C). The freshwater pipeline would consist of a small-diameter, insulated, and heat-traced, high-density polyethylene pipeline. The freshwater pipeline would be placed on VSMs parallel to the water source access road before connecting to shared VSMS with the BT5 infield pipeline to the WOC; Alternative C would include a second freshwater pipeline between the South and North WOCs.

The water from Lakes M0015 and R0064 would be treated in accordance with the State of Alaska Drinking Water Regulations (18 AAC 80), as required for any potable drinking water system. Prior to operation of the freshwater intake system, potable water for construction and drilling camp use would be withdrawn using temporary equipment and trucked to the water plant at the construction camp. Additional freshwater withdrawals from other local permitted lakes would be needed during the construction phase (e.g., ice road and pad construction, hydrostatic pipeline testing, HDD), drilling phase (e.g., drilling support), and operations phase (e.g., dust control); these are described in Section 4.2.5, *Water Use*.

4.2.4.6 Domestic Wastewater

Domestic wastewater treatment infrastructure would be located at the WOC. Sanitary wastes generated from camps would be hauled to the wastewater treatment facility. The treated wastewater would be disposed of in the Class I UIC disposal well located at the WOC, hauled to and disposed of at another approved disposal site (e.g., Alpine), or discharged under the Alaska Pollutant Discharge Elimination System (APDES) General Permit (AKG 33-1000).

Prior to the establishment of the UIC well at the WOC, domestic wastewater would be treated and either hauled to Alpine or Kuparuk (winter only) for injection in an existing UIC disposal well, or in instances where weather or conditions at Alpine prevent disposal, discharged to tundra per APDES permit conditions.

4.2.4.7 Solid Waste

Domestic waste (e.g., food, paper, wood, plastics) would either be incinerated on-site or at Alpine, or, if non-burnable, would be recycled or transported to a landfill facility in Deadhorse (North Slope Borough [NSB] landfill), Fairbanks, or Anchorage. Incinerator ash would be stored on-site until it could be transported to a landfill for disposal. Other hazardous and solid waste from the Project would be managed under Alaska Department of Environmental Conservation (ADEC) and U.S. Environmental Protection Agency (EPA) regulations, as well as BLM BMPs.

4.2.4.8 Drilling Waste

Drilling wastes (e.g., drilling mud, cuttings) would be disposed of on-site through annular disposal (i.e., pumped down the well through the space between the two well-casing strings) and/or transported to an approved disposal well (e.g., Class I UIC disposal well at the WOC). Reserve pits would not be required or used by the Project. A temporary storage cell may be constructed for staging drilling muds and cuttings prior to disposal. Produced water would be processed at the WPF and re-injected to the subsurface through injection wells as part of reservoir pressure maintenance and water flood for secondary recovery. Well work waste materials would be managed according to the *Alaska Waste Disposal and Reuse Guide* (CPAI and BP n.d.). In addition to regulations governing waste handling and disposal, the Project would also be managed under the 2013 BLM BMPs.

4.2.4.9 Fuel and Chemical Storage

Fuel and other chemicals would primarily be stored at the WPF, with additional storage at drill sites. Diesel fuel would be stored in temporary tanks onsite during construction under all action alternatives. During the drilling and operations phases, the WPF would include a diesel fuel supply storage tank(s) and an associated fueling station, as well as a tank farm to store methanol, crude oil flowback, corrosion inhibitor, scale inhibitor, emulsion breaker, and other chemicals as required.

Drill sites would have temporary tanks to support drilling operations, including brine tanks, cuttings and mud tank, and a drill rig diesel fuel tank (built in as part of the drill rig structure). Production operations storage tanks at drill sites would include chemical storage tanks that may contain any of the following (depending on operational needs): corrosion inhibitor, methanol, scale inhibitor, emulsion breaker, anti-foam, and ultra-low-sulfur diesel fuel. Portable oil storage tanks to support well and pad operational activities and maintenance (i.e., well work, well testing) may be present on an as-needed basis.

Fuel and oil storage would comply with local, state, and federal oil pollution prevention requirements, according to the Oil Discharge Prevention and Contingency Plan (ODPCP) and Spill Prevention Control and Countermeasures (SPCC) Plan. Secondary containment for fuel and oil storage tanks would be sized as appropriate to the container type and according to governing regulatory requirements (18 AAC 75 and 40 CFR 112). Fuel and chemical storage for the Project would be managed under BLM BMPs.

4.2.5 Water Use

Freshwater would be required for domestic use at Project camps (e.g., construction, drilling, operations) and for ice road and ice pad construction and maintenance. Potable water estimates are based on a demand of 100 gallons per person per day. Freshwater may also be used for hydrostatic testing of pipelines. Approximately 1.5 MG of water per mile is needed to construct a typical 35-foot-wide ice road (3.0 MG per mile to construct a 70-foot-wide ice road). Approximately 0.25 MG of water is used to construct 1 acre of ice pad. (Note: multi-season ice pads are individually engineered based on geographical and seasonal variables; 0.25 MG of water per acre is a high-level estimate for multi-season ice pads.) Water for construction and maintenance of ice roads and pads would be withdrawn from lakes near the construction activities as allowed by Alaska Department of Natural Resources (ADNR) water rights and temporary water use authorizations; fish habitat permits would be issued by ADF&G where necessary.

Freshwater would be used to make drilling mud, and drilling water requirements are estimated to be 2 MG per well. Water for drilling may be withdrawn from lakes near the Project area using temporary pump and truck connections, as allowed by temporary water use authorizations (ADNR) and fish habitat permits (ADF&G), where necessary. Anticipated total freshwater use is summarized by alternative in Table D.4.2; detailed freshwater use by alternative can be found in Section 4.3.5, *Water Use*; Section 4.4.5, *Water Use*; and Section 4.5.5, *Water Use*.

Table D.4.2. Estimated Total Freshwater Use (millions of gallons) by Alternative and Project Phase

Project Phase	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access
Construction[a]	1,043.5	1,073.7	1,209.9
Drilling[b]	598.1	598.1	600.9
Operations[c]	232.4	375.4	623.0
Total	1,874.0	2,047.2	2,433.8

[a] Construction phase would include ice road construction (1.5 million gallons per mile for 35-foot-wide road and 3.0 million gallons per mile for 70-foot-wide road); ice pad construction (0.25 million gallons per acre); dust suppression; hydrostatic testing; and camp supply (100 gallons per person per day).
[b] Drilling phase would include drilling water (2 million gallons per well); and camp supply (100 gallons per person per day).
[c] Operations phase would include dust suppression; camp supply (100 gallons per person per day); and annual resupply ice road (Alternatives C and D).

Seawater would be required for injection to support enhanced oil recovery and for hydraulic fracturing operations. Approximately 80,000 to 150,000 barrels (3.4 to 6.3 MG) of seawater would be needed per day beginning in 2025 (Alternatives B and C) or 2026 (Alternative D). Seawater would be sourced from the existing Kuparuk Seawater Treatment Plant (STP) at Oliktok Point and would be transported to the Project area from Kuparuk CPF2 via a new seawater pipeline (Section 4.2.2.3, *Other Import/Export Pipelines*).

4.2.6 Gravel Mine Site

The amount of gravel required for the Project varies by alternative and module delivery option (approximately 5.1 to 5.8 million cy depending on alternative and module delivery option). Gravel would be obtained from a new gravel source in the Tiŋmiaqsiuġvik area, approximately 4 to 5 miles southeast of GMT-1 (Figures D.4.1, D.4.2, and D.4.3). The mine site footprint would overlap the Ublutuoch (Tiŋmiaqsiuġvik) River 0.5-mile setback (up to 184.1 acres); however, mine development is allowed in the setback areas (BLM BMP K-1).

4.2.6.1 Mine Site Description

Two 114.8-acre mine site cells located on BLM managed lands in the Tiŋmiaqsiuġvik area (approximately 20 miles from BT3; Figure D.4.6) are currently being evaluated by CPAI for their potential to supply some or all of the gravel required to construct the Project. Both 114.8-acre mine sites are described in the EIS; however, CPAI has not determined the full extent of the required mine site development.

It is likely portions of both sites would be developed with up to a 229.6-acre footprint[2] to supply up to 5.8 million cy of gravel (total gravel volumes vary by alternative and module delivery option). The gravel mine would be accessed seasonally via ice road; no all-season gravel road to the mine site is proposed as part of the Project. The mine pit would be opened for three winter construction seasons (2020–2021, 2021–2022, and 2022–2023; Alternative C would also include 2023–2024) to support construction of BT1, BT2, BT3, WPF, WOC, MTI, airstrip, and associated roads. The pit would be dewatered and reopened for two additional winter construction seasons (2024–2025 and 2025–2026 for Alternatives B; 2025–2026 and 2026–2027 for Alternative C; and 2026–2027 and 2027–2028 for Alternative D) to support construction of BT4 and BT5. There would be activity at the mine site outside of the winter construction season.

The layout of the mine site would be designed to maximize access to the most suitable construction materials while minimizing overall surface disturbance at the site. Overburden removal and gravel mining would proceed as material is needed. The mine site excavation would take place under three separate removal activities:

1. Removal of organic materials
2. Removal of inorganic overburden
3. Removal of suitable gravel material (likely in approximately 20-foot lifts) over 7 to 9 winter construction seasons (a 6- to 8-year period, depending on alternative)

Mining disturbance would occur incrementally over the five or six winter seasons (varies by alternative); for example, only those areas necessary to extract gravel for the 2020–2021 winter construction season would be disturbed during initial mining activities. In subsequent construction seasons, CPAI would conduct initial rehabilitation on previously mined areas using overburden removed from newly mined areas to minimize the overall disturbance footprint. The maximum final mine pit disturbance area following the last winter construction season would be up to 229.6 acres based on initial mine site design plans.

To support gravel mining operations, a 10.0-acre multi-season ice pad and approximately 144 acres of seasonal ice pads would be used for:

- Housing construction equipment (approximately 15 acres)
- Organic overburden stockpile (approximately 6-acre stockpile on an 8-acre ice pad)
- Inorganic overburden stockpile (approximately 55-acre stockpile on a 64-acre ice pad)
- Perimeter pad around the mine site (approximately 57-acre ice pad)

[2] Mine site design is on-going, and the final mine site footprint is anticipated to be less than 230 acres; however, the maximum possible footprint extent (i.e., the conservative value) is used in the EIS for Project impact analysis.

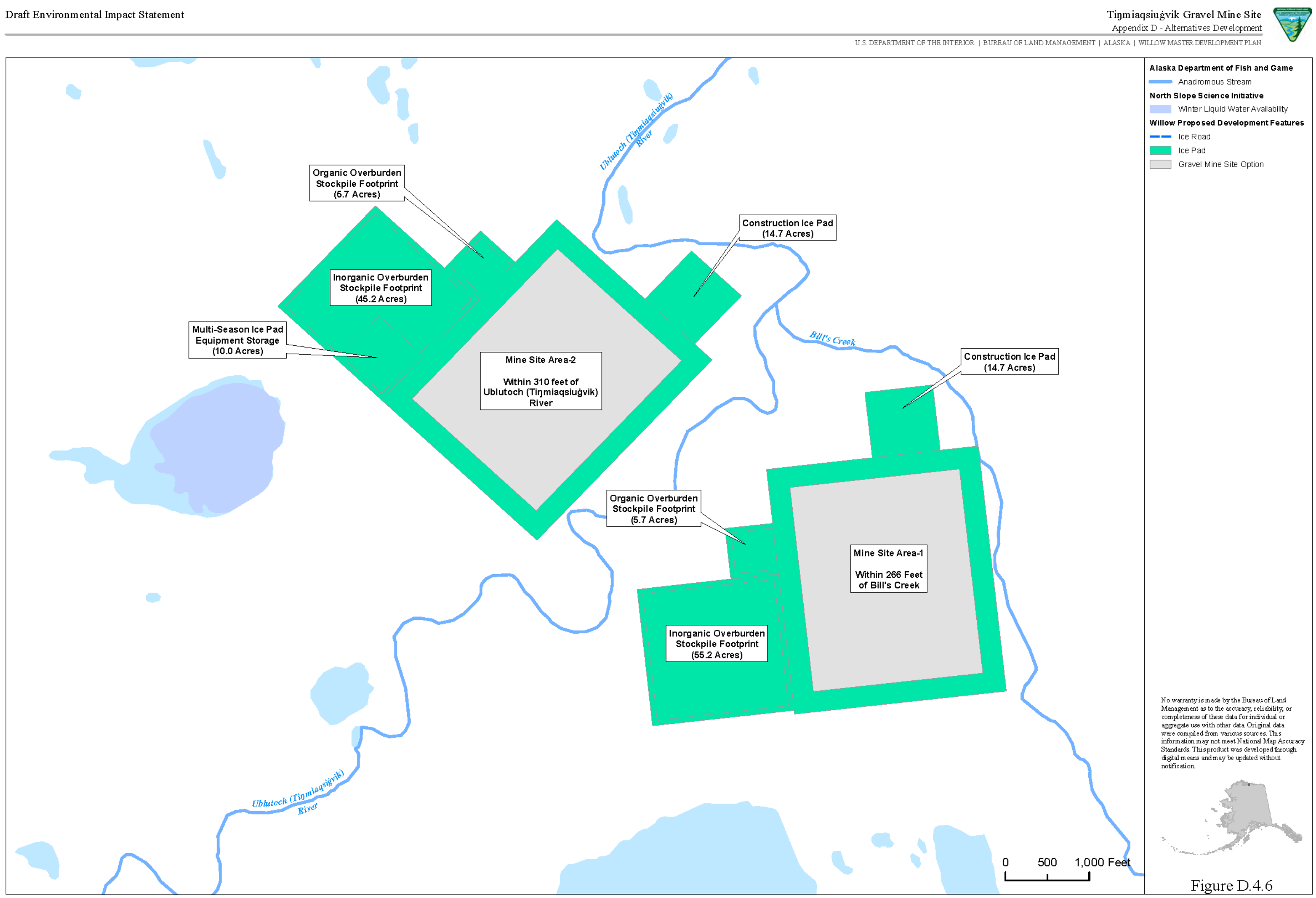

Figure D.4.6. Tiŋmiaqsiuġvik Gravel Mine Site

The overburden storage areas assume stockpile heights of 20 feet, 3:1 side slopes, and a 30 percent material expansion factor. Following the first winter season of mining activities, the inorganic and organic overburden material would be removed from the seasonal ice pad and placed in the excavated mined area to begin mine site rehabilitation and to minimize the mine site footprint. Overburden stockpiling would only be needed for 1 to 2 years of mine development. In subsequent years, the overburden from newly mined areas would be immediately placed in previously mined areas as part of initial mine site rehabilitation. The perimeter side slopes of the excavation area would be graded at 3:1. Pumping would be necessary to maintain a lowered water level throughout mining operations.

Inorganic overburden material would be used to create water diversion berms (approximately 4 feet tall and 8 feet wide) as needed around the mine site perimeter. These dikes would be placed on the surrounding tundra to prevent surface water flow into the mine site, help maintain thermal stability of permafrost adjacent to the mine footprint, and safeguard the stability of the mine walls during mine operation. The dikes would be removed to within 1 foot of the original ground surface elevation upon mine closure.

4.2.6.2 Mine Site Rehabilitation

When the mine site is no longer needed as a gravel source, it would be rehabilitated and allowed to fill with water to provide waterfowl, shorebird, and potentially fish habitat similar to existing habitat in the surrounding area. The rehabilitated mine site would include deepwater habitat. The edge of the littoral shelf would be contoured irregularly to the mine floor, providing a transition to deepwater habitat. Overburden material, including the removed dike material, would be used in finish grading of the rehabilitated mine to form the shallow areas. To promote slope stability and enhance wildlife habitat value, plant cultivation treatments would be applied in accordance with a site-specific revegetation plan.

4.2.7 Erosion and Dust Control

The Project would follow a Facilities Erosion Control Plan (FECP), which would outline procedures for operation, monitoring, and maintenance of various erosion control methods. A Stormwater Pollution Prevention Plan (SWPPP) would describe management of surface water drainage for the Project gravel pads. Both plans would be based on the existing Alpine FECP and Alpine SWPPP.

The FECP would describe snow removal and dust control measures. Snow removal plans would include the use of snow-blowing equipment to minimize gravel dispersion to the tundra and the placement of cleared snow in designated areas. The FECP would discuss snow removal and gravel deposition removal. CPAI would select snow push (i.e., storage) areas annually based on avoiding areas of thermokarst, proximity to waterbodies, and evaluating how the area looks based on previous years’ activities. The dust control plan would include watering gravel roads to minimize dust impacts to the tundra and to maintain gravel road integrity.

CPAI would implement a Project dust control plan to minimize the incidence of fugitive dust. The dust control plan would identify Project sources for fugitive dust, dust control methods and measures to be used for each source, monitoring and record keeping parameters, and plans to address extreme events (i.e., high-wind events). [*The Project dust control plan will be included for the Final EIS as an appendix*.]

4.2.8 Spill Prevention and Response

Facilities would be designed to mitigate spills with spill prevention measures and spill response capabilities. CPAI would implement a pipeline maintenance and inspection program and an employee spill prevention training program to further reduce the likelihood of spills occurring. CPAI’s design of production facilities would include provisions for secondary containment of hydrocarbon-based and hazardous materials, as required by state and federal regulations. If a spill occurs on a pad, the fluid would remain on the pad unless the spill is near a pad edge or exceeds the pad’s retention capacity. Fuel transfers near pad edges would be limited to the extent practicable to mitigate this risk.

In addition to regulations governing spill prevention and response, the Project would be managed under the BLM BMPs described for solid waste and fuel and chemical storage (BLM 2013).

4.2.8.1 Spill Prevention

Spill prevention and response measures that would be used during construction, drilling, and operations would be outlined in a Project ODPCP and SPCC Plan. The intent of the ODPCP and SPCC Plan is to demonstrate CPAI's capability to prevent oil spills from entering the water or land and to ensure rapid response in the event a spill occurs. The ODPCP would comply with applicable State of Alaska requirements (AS 46.04.030, 18 AAC 75) for spill prevention and federal EPA regulations in 40 CFR Part 112, Subpart D (Facility Response Plans). The SPCC Plan would comply with the federal EPA regulations contained in 40 CFR 112.

CPAI would design and construct pipelines to comply with state, federal, and local regulations. Pipelines would be constructed of high-strength steel and would have wall thicknesses in compliance or exceeding design code regulatory requirements. Pipeline welds would be validated using non-destructive examination (i.e., radiography or ultrasonic) during pipeline construction to ensure their integrity and pipelines would be hydrostatically tested prior to operation. The production fluids, water injection, seawater, and export pipelines would be fully capable of accommodating pigs for cleaning and corrosion inspection.

CPAI would use two methods of leak detection for the seawater and diesel pipeline crossings under the Colville River: leak detect mass balance (primary) and optical leak detection (secondary and within the casing). To further prevent a pipeline leak under the Colville River, the diesel and seawater pipelines would be installed inside high-strength casings (pipe). Simultaneous failure of both the pipeline as well as the associated casing is highly unlikely. If diesel or seawater leaked from the pipelines, it would be contained within the space between the outer walls of the pipelines and the inner wall of the casing, rather than reaching the subsurface river environment. The design is analogous to secondary containment provided as a spill prevention technique for storage tanks. The casing would perform a second function, accommodating the external loads that would normally be carried by the pipelines. The casing and pipelines would not apply substantial, direct loads onto the other, with some load transferred by the plastic casing isolators attached to the carrier pipeline. A deformation of the casing pipe would not necessarily cause deformation of the carrier pipelines, thus providing protection against external loads. To prevent external corrosion, the casing and pipelines would be protected by an abrasion resistant coating in accordance with industry standards.

There would be an increased potential for pipeline spills where pipelines would cross under roads due to corrosion of the buried portion of the pipelines. The likelihood of corrosion occurring would be reduced through design and monitoring. CPAI would maintain corrosion control and inspection programs that include ultrasonic inspection, radiographic inspection, coupon monitoring, metal loss deflection pigs and geometry pigs (applicable to pig-capable pipelines), and forward-looking-infrared (FLIR) technology. The inspection programs are API Standard 570-based programs that focus inspection efforts on areas with the greatest potential for spills.

4.2.8.2 Spill Response

CPAI would implement the Project's ODPCP and SPCC Plan to minimize accidental oil spills and impacts. Through the ODCP, CPAI would demonstrate that readily accessible inventories of fit-for-purpose oil spill response equipment and personnel would be available for use at Project facilities. In addition, a state-registered primary response action contractor would serve as CPAI's primary response action contractor and would provide trained personnel to manage all stages of a spill response, including containment, recovery, and cleanup.

The threat to rivers and streams from a possible pipeline spill would be minimized by quickly intercepting, containing, and recovering spilled oil near the waterway-pipeline crossing points. The road would be used for access and staging for spill response.

Spill-response equipment would be pre-staged at strategic locations across the Project area as outlined in the ODPCP for an initial response. This strategy would facilitate the rapid deployment of equipment by personnel. The effective response time would be enhanced with pre-staged equipment, which would expedite equipment deployment to contain and recover spilled oil, reducing the overall affected area.

During summer, pre-staged containment booms would be placed at strategic locations near selected river channels to facilitate a rapid response. A pre-deployed boom may also be placed within selected stream channels to mitigate a spill, should one occur. During summer, spill containment equipment would likely be staged or deployed using helicopters. In the event a spill occurs, spill response activity could include the use of watercraft (e.g., airboats, jetboats) to access potentially affected areas.

4.2.8.3 Spill Training and Inspections

CPAI provides regular training for its employees and contractors on the importance of preventing oil or hazardous material spills, including new-employee orientation, annual environmental training seminars, and appropriate certification classes for specific issues covering spill prevention. CPAI's employees and contractors participate in frequent safety meetings that address spill prevention issues, as appropriate. The CPAI Incident Management Team participates in regularly scheduled training programs and conducts spill response drills in coordination with federal, state, and local agencies. Employees are encouraged to participate in the North Slope Spill Response Team (NSSRT) and as part of the NSSRT, members receive regularly scheduled spill response training to ensure the continuous availability of skilled spill responders on the North Slope.

CPAI is required to conduct visual examinations of pipelines and facility piping at least monthly during operations. CPAI would provide aerial overflights as necessary to allow inspection both visually and with the aid of FLIR technology, when required. FLIR technology, employed either aerially using aircraft or from the ground using handheld systems, allows for spill identification based on the temperature "signature" resulting when warm fluids leak. FLIR technology can detect warm spots in low-light conditions or when other circumstances such as light fog or drifted snow limit visibility. FLIR technology can also identify trouble spots along pipelines, such as damaged insulation, before a problem develops. CPAI would also conduct regular visual inspections of facilities and pipelines from gravel roads, where available, and from ice roads and aircraft for sections of pipelines not paralleled by gravel roads (Alternatives C and D).

4.2.9 Abandonment and Reclamation

The abandonment and reclamation of Project facilities would be determined at or before the time of abandonment. The plan for abandonment and reclamation is subject to input from federal, state, and local authorities and private landowners. Other stakeholders would also provide comment on the abandonment and reclamation plan. Controlling factors for the abandonment and reclamation plan may include:

- BLM leases, applications for permits to drill, and right-of-way
- USACE Section 404 permit
- State of Alaska easement(s)
- Alaska Oil and Gas Conservation Commission requirements for plugging and abandonment of wells
- NSB Title 19 requirements
- Private agreements addressing private lands

The abandonment and reclamation of Project facilities may involve removing gravel pads and roads, or alternatively leaving them in place for future use by a different entity. Revegetation of abandoned gravel facilities may be accomplished by seeding with native vegetation or by allowing natural colonization. Depending on the types of abandonment and reclamation activities that occur, summer road and air traffic levels would be similar to those experienced during construction activities, but at potentially lower intensity levels and shorter durations.

If the gravel infrastructure is removed as part of the reclamation process, it could be used for other development projects. To assist with abandonment and reclamation, BLM holds bonds from any company conducting development activities within the NPR-A to cover the cost of reclamation. CPAI also sets money aside to cover asset retirement obligations. Reclamation standards are determined by the BLM authorized officer at the time of reclamation.

4.2.10 Schedule and Logistics

Timing of the Project is based on several factors including permitting and other regulatory approvals, project sanctioning, and purchase and fabrication of long-lead time components. CPAI proposes to construct the Project over approximately 7 to 9 years beginning in the first quarter (Q1) of 2021. The WPF is anticipated to come online the fourth quarter (Q4) of 2024 (first oil) for Alternatives B and C, and in Q1 of 2026 for Alternative D. Operations would run to the end of the Project's field life, which is estimated to be 2050 (Alternatives B and C) or 2052 (Alternative D). Table D.4.3 provides a project schedule overview. Detailed schedules for each action alternative are provided in: Alternative B, Section 4.3.8, *Schedule and Logistics*; Alternative C, Section 4.4.8, *Schedule and Logistics*; and Alternative D, Section 4.5.8, *Schedule and Logistics*.

Table D.4.3. Project Schedule Overview by Alternative and Project Milestone

Project Milestone	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access
Life of Project	30 years (2021 through 2050)	30 years (2021 through 2050)	32 years (2021 through 2052)
Construction	7 years (2021 through 2027)	8 years (2021 through 2028)	9 years (2021 through 2029)
Drilling[a]	11 years (2023 through 2033)	11 years (2023 through 2033)	11 years (2024 through 2034)
Operations	27 years (2024 through 2050)	27 years (2024 through 2050)	27 years (2026 through 2052)
First oil	2024	2024	2026

[a] Drilling would consist of BT1 pre-drilling activity (2 years) before the Willow processing facility is operational; development drilling (9 years) would commence after the Willow processing facility is operational. During pre-drilling, drilling rigs would operate on diesel generators and during development drilling, drill rigs would operate on electrical power provided by the Willow processing facility.

4.2.10.1 Construction Phase

Gravel mining and placement would be conducted almost exclusively during winter. Prepacking snow and ice road construction to access the gravel mine site and gravel road and pad locations would occur in December and January, with ice roads assumed available for use by February 1, pending tundra travel authorization approvals from regulatory agencies.

Gravel for the gravel infrastructure associated with initial construction (access road [Alternatives B and C], BT1, BT2, BT3, connecting roads, WPF, WOC, and airstrips) would be mined and placed during winter (January through April) of the first 3 to 4 years of construction (varies by alternative). Two additional winter seasons of gravel mining and placement would occur to construct BT4, BT5, and associated roads.

Gravel roads and pads would be built by constructing an ice road followed by laying gravels. Gravel conditioning (turning the upper layers once or twice during the summer to expose, thaw and dewater the deeper layers) and re-compaction would occur later that same year (likely in August and September). Culvert locations would be identified (as described in Section 4.2.3.2.2, *Culverts*) and culverts would be installed per the final design during the first construction season prior to spring breakup. Additional culverts may be placed after spring breakup as site-specific needs are further assessed. Bridges would be constructed during winter from ice roads and pads.

Once gravel pads are constructed, on-pad facility construction and installation would commence. Modules for the WPF, BT1, BT2, and BT3 would be delivered by sealift barge to the Proponent's MTI or Point Lonely MTI during summer (Section 4.7, *Sealift Module Delivery Options*). Modules would be staged on the MTI until the following winter construction season when they would be transported to the WPF via sea- and land-based ice road. The location of the ice roads would vary based on sealift barge deliver location. Modules for BT4 and BT5 would be delivered via a second sealift and moved to the Project area in the same manner as modules for BT1, BT2, and BT3.

Pipelines would be installed during winter from ice roads. First, VSM locations would be surveyed and drilled. In most locations, a VSM and HSM would be assembled and installed using a sand slurry for backfill around the VSM. Alternatively, VSMs may be driven into an undersized borehole using a vibratory hammer. Engineering design would determine which method would be used for any given set of

VSMs. The pipelines would be strung, welded, tested, and installed on pipe saddles atop the HSMs. The HDD Colville River pipeline crossing would be completed during the winter construction season of 2022 (Section 4.2.2.3, *Other Import/Export Pipelines*). Pipeline installation would take between 1 and 3 years per pipeline, depending on pipeline length and location.

4.2.10.2 Drilling Phase

Drilling is planned to begin in 2023 (Alternatives B and C) or 2024 (Alternative D) at BT1. The drill rig would be mobilized to the Project area and drilling would begin prior to completion of the WPF and drill site facilities. This "pre-drilling" period would last approximately 18 to 24 months and would allow the WPF to be commissioned immediately following construction by timing completion of a sufficient number of wells to provide the minimum fluid rates to commission the pipelines and facility. Pre-drilling would eliminate a 1- to 2-year delay between construction and production of first oil. It is assumed the wells would be drilled consecutively from BT1 to BT3 to BT2; however, CPAI would determine the final timing and order of drilling based on economics and drill rig availability. A second drill rig may be brought to the Project site during the drilling phase.

Drilling is anticipated to take 10 to 11 years and would be conducted year-round with an anticipated progress rate of approximately 20 to 30 days per well.

4.2.10.2.1 Hydraulic Fracturing

Hydraulic fracturing is a process used to increase the flow of fluids from a reservoir into the wellbore and to establish a connection between oil-bearing formation layers. Each production well would receive a multistage hydraulic fracturing operation similar to those employed at other North Slope developments. The process would involve isolating a portion of the reservoir to be fractured and then pumping gelled seawater or brine mixed with a proppant (small beads of sand or human-made ceramic material) at high pressure into the formation. The high-pressure fluid would create fractures in the formation, and the proppants would prevent the fracture from closing, allowing oil and gas within the formation to flow into the wellbore and ultimately the surface.

It is anticipated each well would be hydraulically fractured one time with approximately 12 to 20 individual fracturing locations within the well. Hydraulic fracturing operations would last approximately 6 days per well with six wells per pad per year being fracture stimulated. Two hydraulic fracturing operations could occur concurrently, though not on the same pad; however, fracturing operations may occur simultaneously with well drilling on the same pad. Total water use for hydraulic fracturing would be approximately 14,000 to 24,000 barrels (0.6 to 1.0 MG) of seawater.

The Alaska Oil Gas Conservation Commission (AOGCC) maintains jurisdiction over the sub-surface fracturing process (20 AAC 25.283). AOGCC regulations specifically require disclosure of chemicals used in the hydraulic fracturing process, including the anticipated volume of fluids to be used in the operation. Other agencies (e.g., EPA, ADEC, ADNR) maintain some regulatory oversight, though this is primarily limited to surface activities associated with the equipment and materials used in the process.

4.2.10.3 Operations Phase

Following initial well drilling and WPF start-up, typical operations would consist of well operations and production, and transportation of produced hydrocarbons. Under Alternatives B and C, production from BT1, BT3, and BT2 would begin in Q4 of 2024, second quarter (Q2) 2025, and Q4 2025, respectively; under Alternative D, production from BT1, BT3, and BT2 would begin in Q1 2026, Q4 2026, and Q4 2027, respectively. The schedule for production for Alternatives B from BT4 could begin as early as Q4 of 2026 and from BT5 as early as Q4 of 2027. For Alternative C, the production schedule for BT4 could begin in Q4 of 2027 and BT5 in Q4 of 2028. For Alternative D, production would be further delayed with production beginning in Q4 of 2028 from BT1 and Q4 of 2029 from BT5. Well maintenance operations would occur intermittently throughout the life of the Project. CPAI's standard operations and maintenance practices would be implemented for this Project phase.

4.2.11 Project Infrastructure in Special Areas

All action alternatives would include Project infrastructure located in BLM-identified Special Areas.

Alternatives B and C would construct approximately 1 mile of road and pipeline, and Alternative D would construct approximately 1 mile of pipeline in the 1977 designated Colville River Special Area (CRSA) (BLM 2008a). In making this designation, the Secretary of the Interior stated:

> *…the central Colville River and some of its tributaries provide critical nesting habitat for the arctic peregrine falcon, an endangered species. The bluffs and cliffs along the Colville River provide nesting sites with the adjacent areas being utilized as food hunting areas* (42 FR 28515, June 3, 1977).

The CRSA is approximately 2.4 million acres and includes lands around the Colville River. The Project infrastructure would avoid setbacks established along the Colville River to protect arctic peregrine falcon nesting habitat in the CRSA (Protection 1 in BLM [2008] and BMP K-1 in BLM [2013]). Consistent with BLM BMP K-7 (BLM 2013), in designing the Project, CPAI made reasonable and practicable efforts to locate permanent facilities as far from raptor nests as feasible and to minimize loss of potential raptor foraging habitat, with consideration for other potential impacts.

All action alternatives would include drill sites BT2 and BT4 and associated roads and pipelines within the Teshekpuk Lake Special Area (TLSA); under Alternative C the North WOC and airstrip would also be within the TLSA. The TLSA was established in 1977 (BLM 2013) with the purpose of protecting caribou calving and insect-relief areas and waterbird and shorebird breeding, molting, staging, and migration habitats. As described in BLM (2013):

> *…designation of lands as a Special Area carries with it no specific restrictions on activities. It does require, however, that activities be conducted in a manner which will assure the maximum protection of surface values [as identified by the Secretary for the Special Area] to the extent consistent with the requirements of the [Naval Petroleum Reserve Production Act] NPRPA for exploration and production activities.*

4.2.12 Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices

Due to technical constraints, some Project facilities may require deviations from NPR-A lease stipulations and BMPs (Section 2.1., *Lease Stipulations and Existing Best Management Practices in the National Petroleum Reserve in Alaska*). The likely deviations are described in Table D.4.4. Each identified deviation would be reviewed as the Project design engineering advances for opportunities to conform to the lease stipulations and BMPs to the extent practicable. The specific number and locations of these deviations for each action alternative is described in Section 4.3, *Alternative B: Proponent's Project*; Section 4.4, *Alternative C: Disconnected Infield Roads*; and Section 4.5, *Alternative D: Disconnected Access*.

Table D.4.4. Anticipated Deviations from National Petroleum Reserve in Alaska Lease Stipulations or Best Management Practices

Lease Stipulation or Best Management Practice[a]	Best Management Practice Description	Applicable Alternative[b]
E-2	*Objective*: Protect fish-bearing waterbodies, water quality, and aquatic habitats. *Requirements/standard*: Permanent oil and gas facilities, including roads, airstrips, and pipelines, are prohibited within 500 feet from the ordinary high-water mark of fish-bearing waterways. *Reason for deviation*: LS E-2 requires a 500-foot setback from fish-bearing waterbodies, although essential pipeline and road crossings are permitted on a case-by-case basis. Deviations from this LS are warranted because compliance is technically infeasible due to the hydrology and number of waterbodies in the Project area. As a result, it is not possible in all instances to avoid encroachment within 500 feet of every waterbody. All action alternatives include essential road and pipeline crossings of fish-bearing waterbodies and freshwater intake pipelines at Lakes M0015 and R0064.	All
E-5	*Objective*: Minimize impacts of the development footprint. *Requirements/standard*: Facilities shall be designed and located to minimize the development footprint. Issues and methods to be considered include: Sharing facilities with existing development; colocation of all oil and gas facilities, except airstrips, docks, and seawater treatment plants, with drill site pads; integration of airstrips with roads. *Reason for deviation*: All alternatives would place new VSMs along existing pipeline corridors due to pipe rack capacity limits; all alternatives would separate the proposed airstrip(s) from roads due to Federal Aviation Administration regulations and operational safety concerns based on incident history at the Alpine integrated airstrip; and under Alternative C, the Willow processing facility would not be colocated with a drill site pad.	All
E-7	*Objective*: Minimize disruption of caribou movement and subsistence use. *Requirement/standard*: Pipelines and roads shall be designed to allow the free movement of caribou and the safe, unimpeded passage of the public while participating in subsistence activities. Design standards include: Pipelines shall be elevated a minimum of 7 feet above the surrounding ground surface; crossing ramps may be required; and a minimum distance of 500 feet between pipelines and roads shall be maintained. *Reason for deviation*: While BMP E-7 requires a minimum distance of 500 feet between pipelines and roads, it is acknowledged this may not be feasible in all areas. In these cases, alternative designs would be considered by the authorized officer. Initial pipeline alignments have identified that the minimum distances would not be feasible in all areas for all action alternatives based on road and pipeline design constraints. Deviations would occur where roads and pipelines converge on a drill site pad or at narrow land corridors between lakes where it is not possible to maintain 500 feet separation between pipelines and roads without increasing potential impacts to waterbodies.	All
E-11	*Objective*: Minimize the take of species, particularly those listed under the Endangered Species Act and BLM Special Status Species, from direct or indirect interaction with oil and gas facilities. *Requirement/standard*: Specific requirements for surveys, facility siting, and facility design vary based on species (which includes spectacled and Steller's eiders and yellow-billed loons). *Reason for deviation*: All action alternatives would cross the default standard mitigation disturbance setback of 1 mile around recorded nest sites for yellow-billed loons and 500-meter (1,625-feet) setback of the shoreline of nest lakes.	All

Lease Stipulation or Best Management Practice[a]	Best Management Practice Description	Applicable Alternative[b]
K-1	*Objective*: Minimize the disruption of natural flow patterns and changes to water quality; minimize the disruption of natural functions resulting from the loss or change to vegetative and physical characteristics of floodplain and riparian areas; minimize the loss of spawning, rearing, or over-wintering fish habitat; minimize the loss of cultural and paleontological resources; minimize the loss of raptor habitat; minimize the disruption of subsistence activities; and minimize impacts to scenic and other resources. *Requirement/standard*: Permanent oil and gas facilities, including gravel pads, roads, airstrips, and pipelines are prohibited in stream beds and adjacent to rivers listed. Rivers in the Project area that are listed include Colville River (2-mile setback), Fish (Uvlutuuq) Creek (3-mile setback), Judy (Iqalliqpik) Creek (0.5-mile setback), and Ublutuoch (Tiŋmiaqsiuġvik) River (0.5-mile setback). *Reason for deviation*: Alternatives B and D would include essential road and pipeline crossings of Judy (Iqalliqpik) and Fish (Uvlutuuq) creeks; Alternative C would include an essential road and pipeline crossing of Fish (Uvlutuuq) Creek and an essential pipeline crossing of Judy (Iqalliqpik) Creek. Pipeline valve pads would also be located within the prescribed setbacks under all action alternatives.	All
K-2	*Objective*: Minimize the disruption of natural flow patterns and changes to water quality; minimize the disruption of natural functions resulting from the loss or change of vegetative and physical characteristics of deepwater lakes; minimize the loss of spawning, rearing, or overwintering fish habitat; minimize the loss of cultural and paleontological resources; minimize impacts to subsistence cabins and campsites; and minimize the disruption of subsistence activities. *Requirement/standard*: Permanent oil and gas facilities, including gravel pads, roads, airstrips, and pipelines, are generally prohibited on the lake or lakebed within 0.25 mile of the ordinary high-water mark of any deep lake (i.e., depth greater than 13 feet). *Reason for deviation*: All action alternatives would have a freshwater intake system at Lake M0015, a previously identified deepwater lake.	All

Note: BMP (best management practice)
[a] Lease stipulations and best management practices identified in BLM (2013).
[b] Excludes essential road and pipeline crossings.

The Point Lonely MTI (Option 2; Section 4.7.2) would require the use of existing gravel infrastructure located in a portion of the K-5 Teshekpuk Lake Caribou Habitat Area which prohibits construction of new non-subsistence infrastructure. The NPR-A IAP/EIS ROD (2013) states that, "construction, renovation, or replacement of facilities on the existing gravel pads at Camp Lonely and Point Lonely may be permitted if the facilities will promote safety or environmental protection." Because use of existing gravel facilities would minimize environmental impacts, it would promote environmental protection. Consequently, use of the existing infrastructure at Point Lonely (Section 4.7.2, *Option 2: Point Lonely Module Transfer Island*) conforms with the IAP and no deviation to existing BMPs is necessary.

4.3 Alternative B: Proponent's Project

Alternative B would extend an all-season gravel road from the GMT-2 development southwest, toward the Project area (Figure D.4.1). The access road would end at the WPF, which would be colocated with Bear Tooth drill site BT3 (BT3), and adjacent to an airstrip and the WOC. Gravel roads would extend north (connecting to BT1, BT2, and BT4) and south (connecting to BT5) of the access road. From the road to BT5, a water source access road would extend east to a water source access pad and water intake system at Lakes M0015 and R0064. Just east of the airstrip, a gravel road would extend north, crossing Judy (Iqalliqpik) Creek before reaching BT1. From BT1, the road would continue north, crossing Judy (Kayyaaq) Creek, to reach BT2 before crossing Fish (Uvlutuuq) Creek and ending just outside the eastern boundary of the K-5 Teshekpuk Lake Caribou Habitat Area at BT4. Alternative B would construct 7 bridges (1 on the road extending from GMT-2 and 6 on the roads to Project pads). Infield (multiphase) pipelines would connect individual drill sites to the WPF and export/import pipelines would connect the WPF to existing infrastructure on the North Slope.

Sealift module delivery to the Project area from either the Proponent's MTI or Point Lonely MTI would be required (Section 4.7, *Sealift Module Delivery Options*).

The proposed road alignment provides direct gravel-road access from the existing gravel road network in the GMT and Alpine developments to the proposed Project facilities. The full, all-season gravel road access connection to the Alpine development would provide for additional operational safety and risk reduction by providing redundancies and additional contingencies for each project; and would provide support for reasonably foreseeable future actions described in Table E.19.1 in Appendix E.20, *Cumulative Effects Technical Appendix*. Table D.4.5 provides a summary of Project components and their associated footprint for Alternative B.

Alternative B is BLM's preferred alternative. The identification of a preferred alternative does not constitute a commitment or decision; if warranted, BLM may select a different alternative than the preferred alternative in its Record of Decision.

Table D.4.5. Summary of Components for Alternative B: Proponent's Project

Project Component	Description
Drill site gravel pads	Four 14.5-acre pads (58.0 acres total): BT1, BT2, BT4, and BT5 (BT3 would be colocated with the WPF)
Willow processing facility gravel pad	WPF colocated with BT3; 34.1-acre pad
Willow Operations Center gravel pad	21.6-acre pad located near BT3/WPF and airstrip
Water source access gravel pads	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064
Other gravel pads	Four valve pads (1.3 acres total); 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing HDD pipeline pads (2 total) at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre total) Pipeline crossing pad near GMT-2 (0.5 acre total)
Single season ice pads	Used during construction at the gravel mine site, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (767.6 total acres)
Multi-season ice pads	10.0-acre multi-season ice pad near GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad near WOC (Q1 2021 to Q2 2022) 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2022)
Infield pipelines	31.6 total miles: BT1 to WPF (7.3 miles); BT2 to BT1 (5.2 miles); BT4 to BT2 (9.4 miles); BT5 to WPF (7.5 miles); water source to WOC (2.2 miles)
Willow export pipeline	36.5 total miles on new VSMs (WPF to tie-in pad near Alpine CD4N)
Other pipelines	67.1-mile seawater pipeline from Kuparuk CPF2 to WPF on new VSMs 33.9-mile diesel pipeline from Kuparuk CPF2 to Alpine CD4N on new VSMs (30.8 miles) and CD4N to the Alpine processing facility at Alpine CD1 on existing VSMs (3.1 miles)
Gravel roads	38.2 miles (285.3 acres) total connecting drill sites to the WPF, WPF to GMT-2, airstrip, and lighting and water source access roads (total acres includes vehicle turnouts) Eight turnouts with subsistence/tundra access ramps (3.0 acres total)
Bridges	Seven total at Judy (Iqalliqpik) Creek, Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 2, Willow Creek 4, Willow Creek 4A, and Willow Creek 8
Airstrip	5,600 × 200–foot airstrip and apron (39.3 acres total); would also require airstrip access and lighting access roads
Ice roads	Approximately 372.0 total miles (2,074.7 total acres) over seven construction seasons
Total gravel footprint and gravel fill volume[a]	442.7 acres using 4.7 million cubic yards of gravel
Gravel source	Up to 230-acre site in Tiŋmiaqsiuġvik area

Project Component	Description
Total freshwater use	1,874.0 million gallons over the life of the Project (30 years)
Ground traffic (number of trips)[b, c]	3,009,933
Fixed-wing air traffic[b, d]	35,713 total flights Willow: 34,464 Alpine: 1,249
Helicopter air traffic[b]	2,478 total flights Willow: 2,337 Alpine: 141
Fish-bearing waterbody setback overlap (LS E-2)	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines
Less than 500-foot pipeline-road separation (BMP E-7)	12.4 miles of pipelines and road with less than 500 feet of separation
Yellow-billed loon setback overlap (BMP E-11)	56.7 acres of gravel infrastructure and 6.9 miles of pipelines within 1 mile of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests
River setback overlap (BMP K-1)	Colville River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.6 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 16.7 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines
Deepwater lake setback overlap (BMP K-2)	2.2 acres of gravel infrastructure and 0.2 mile of pipelines

Note: BMP (best management practice); BT1 (drill site BT1); BT2 (drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); GMT-2 (Greater Mooses Tooth 2); HDD (horizontal directional drilling); LS (lease stipulation); MTI (module transfer island); Q1 (first quarter); Q2 (second quarter); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)

[a] Values may not sum to totals due to rounding.

[b] Total traffic for 30-year life of the Project (not including reclamation activity). Ground-traffic trips are one-way; a single flight is defined as a landing and subsequent takeoff.

[c] Number of trips includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Construction ground traffic also includes gravel hauling (e.g., B70/maxi dump trucks).

[d] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse); includes C-130, Twin Otter/CASA, Cessna, and DC-6 or similar aircraft.

4.3.1 Project Facilities and Gravel Pads

Project facilities proposed for the WPF, drill sites, and WOC for Alternative B are described in Section 4.2.1, *Project Facilities and Gravel Pads*. Under Alternative B, the BT3/WPF pad location would be approximately 13 miles by gravel road from GMT-2.

4.3.2 Pipelines

Alternative B pipelines (Figure D.4.7) would include infield pipelines connecting each drill site to the WPF and the Willow Pipeline (oil export) connecting the WPF to existing facilities at Alpine. Additional pipelines would include a seawater import pipeline from Kuparuk CPF2 to the WPF, a diesel import pipeline from Kuparuk CPF2 to the Alpine processing facility (located at Alpine CD1), and a freshwater pipeline from the water source access pads to the WOC (Figure D.4.7). Alternative B pipelines would place 14 total VSMs (typically 24-inch diameter) below OHW; all VSMs would be installed using the drill-set-slurry method. Pipeline design would be as described in Section 4.2.2, *Pipelines*.

Table D.4.6 summarizes pipeline infrastructure under Alternative B by pipeline segment.

Table D.4.6. Alternative B Pipeline Segments Summary

Pipeline Segment	Pipeline	Segment Length (miles)	Notes
BT4 to BT2 intersection	BT4 infield[a]	9.4	Pipelines on new VSMs
BT2 to BT1	BT2 infield[a]	5.2	Pipelines on new VSMs Would also transport BT4 materials
BT1 to WPF	BT1 infield[a]	7.3	Pipelines on new VSMs Would also transport BT4 and BT2 materials
BT5 to WPF	BT5 infield[a]	7.5	Pipelines on new VSMs
Water source to WOC	Freshwater	2.2	Shares other infield VSMs for 0.8 mile
BT3/WPF to CD4N tie-in pad	Willow export	36.5	Shares new VSMs with seawater pipeline
CPF2 to BT3/WPF	Seawater	67.1	Shares new VSMs with Willow Pipeline from BT3 to CD4N; shares new VSM with diesel pipeline from CD4N to Kuparuk CPF2; includes new HDD crossing of the Colville River adjacent to existing HDD crossing
CPF2 to CD1	Diesel	34.0	Shares new VSMs with seawater from Kuparuk CPF2 to Alpine CD4N and existing VSMs from Alpine CD4N to Alpine CD1; includes new HDD crossing of the Colville River adjacent to existing HDD crossing

Note: BT1 (drill site BT1); BT2 (Drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); CD1 (Alpine CD1); CD4N (Alpine CD4N); CPF2 (Kuparuk CPF2); GMT-2 (Greater Mooses Tooth 2); HDD (horizontal directional drilling); VSM (vertical support member); WPF (willow processing facility)

[a] Infield pipelines include produced fluids, injection water, gas, and miscible-injectant pipelines.

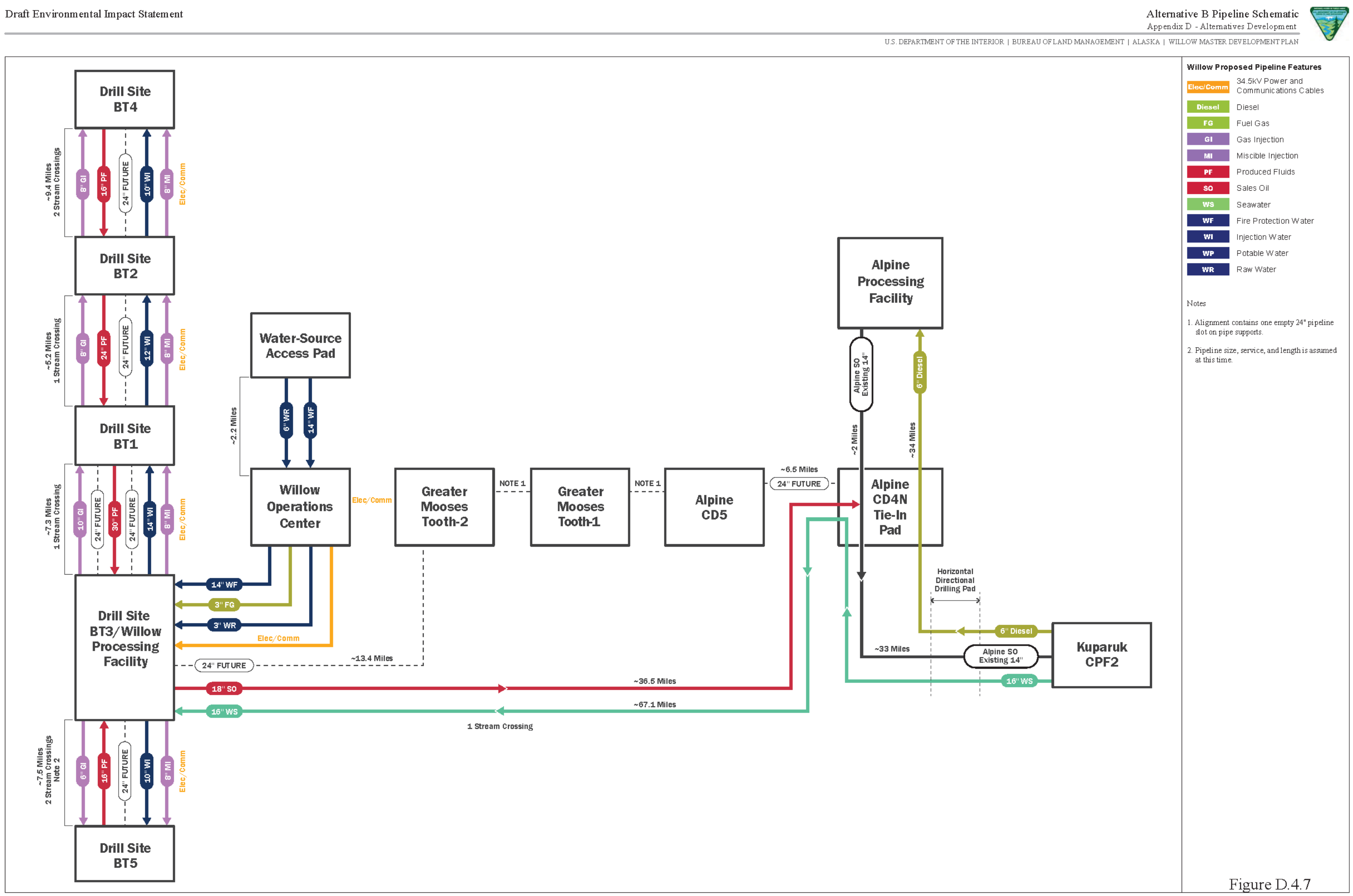

Figure D.4.7. Alternative B Pipeline Schematic

All pipelines would parallel gravel roads to facilitate routine visual observation and investigation of pipelines. Conducting visual observation and investigation of pipelines from a gravel road would reduce the number and frequency of aircraft flights required to visually inspect pipelines.

The Willow Pipeline (oil export) and seawater pipeline would be constructed on new VSMs from the WPF to the tie-in pad near Alpine CD4N (Willow Pipeline) and Kuparuk CPF2 (seawater pipeline), as described in Section 4.2.2*, Pipelines*. The diesel pipeline would be placed on new VSMs (shared with the seawater pipeline) between Kuparuk CPF2 and Alpine CD4N, and on existing VSMs from CD4N to the Alpine processing facility located at Alpine CD1. From Alpine CD1, diesel fuel would be trucked to the WPF and other facilities. In total, 267.0 miles of pipelines would be constructed with 263.9 miles of pipelines on new VSMs (approximately 98.8%) and 3.1 miles of pipelines on existing VSMs (approximately 1.2%) using 96.3 miles of new and existing pipeline corridors. Infield pipelines would connect each drill site to the WPF. Where practicable, infield pipelines would tie in to other infield pipelines (Section 4.2.2.1, *Infield Pipelines*) to minimize redundant parallel pipelines.

4.3.3 Access to the Project Area

Alternative B would include seasonal ice road access to support construction; access to BT3/WPF from GMT and Alpine developments via an all-season gravel road; access from BT3/WPF to individual drill sites via all-season gravel roads; and helicopter and fixed-wing aircraft to the Project and Alpine airstrips. Table D.4.7 provides a summary of total traffic volumes anticipated for the Project under Alternative B by transportation type and year.

Table D.4.7. Alternative B Total Project Traffic Volumes for the Life of the Project

Year	Ground[a]	Fixed-Wing Trips Alpine[b]	Fixed-Wing Trips Willow[b]	Helicopter Trips Alpine[c]	Helicopter Trips Willow[c]
2020	0	0	0	50	0
2021	120,442	252	0	50	0
2022	161,196	477	26	41	41
2023	209,855	52	918	0	82
2024	258,643	52	918	0	82
2025	224,468	52	1,724	0	82
2026	232,510	52	1,724	0	82
2027	186,603	52	1,525	0	82
2028 to 2032	520,826	260	6,515	0	410
2033 to 2050	1,095,390	0	21,114	0	1,476
Total	3,009,933	1,249	34,464	141	2,337

Note: Trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff.
[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks).
[b] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.
[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection during all phases of the Project.

During construction, ice roads would be constructed to support Project pipeline, gravel pad and gravel road construction, and gravel source (Tiŋmiaqsiuġvik mine site) access over seven winter construction seasons. (The Project would receive annual resupply via the Alpine ice road, which is constructed annually between Kuparuk and Alpine to support Alpine operations. This ice road mileage is not included in the Project's analyses as it would be constructed regardless in support of the Alpine development.) Ice road design and mileage is described in Section 4.2.3.1, *Ice Roads*.

Gravel roads would provide year-round access between the GMT and Alpine developments and the Project area and from the WPF to individual drill sites. Alternative B gravel roads would require construction of seven bridges (Table D.4.8) following the design described in Section 4.2.3.2.1, *Bridges*. Five of the seven bridges would require the placement of 56 total piles (ranging from 36- to 42-inch diameter) below OHW (Table D.4.8). Alternative B would also require 11 additional culverts or culvert batteries at stream or swale crossings (Figure D.4.1) and 202 cross-drainage culverts.

Table D.4.8. Alternative B Bridges Summary

Waterbody Crossing	Bridge Length (± feet)[a]	Piles Below Ordinary High Water (number)	Latitude (North)	Longitude (West)
Judy (Iqalliqpik) Creek	420	20	70.1462	152.0914
Judy (Kayyaaq) Creek	75	4	70.1848	152.1211
Fish (Uvlutuuq) Creek	500	24	70.2526	152.1787
Willow Creek 2	80	4	70.1413	151.9557
Willow Creek 4	130	4	70.0816	152.1302
Willow Creek 4a	50	0	70.0360	152.2015
Willow Creek 8	40	0	70.2635	152.1806

[a] Bridge lengths are approximations based on interpretation of available aerial imagery and are subject to change.

The airstrip would be constructed in the winter construction season of 2021–2022 and located near the WOC (Section 4.2.3.3, *Airstrip and Associated Facilities*). Prior to airstrip availability, the Alpine airstrip (located at Alpine CD1) would be used to support the Project. Helicopters would be used during Project construction to support ice road construction, environmental monitoring, and surveying. Following construction of gravel roads, and during the drilling and operations phases, helicopter use would primarily be limited to ongoing environmental monitoring and spill response support.

Sealift barges would be used to deliver processing and drill site modules to the North Slope via the MTI at Atigaru Point or Point Lonely (Section 4.7, *Sealift Module Delivery Options*). No additional or regular use of barges is proposed over the life of the Project.

4.3.4 Other Infrastructure

4.3.4.1 Ice Pads

Single- and multi-season ice pads would be used to support Project construction. Single-season and multi-season ice pads are described in Section 4.2.4.1, *Ice Pads*.

Alternative B would require 767.6 acres of single-season ice pads over the life of the Project (30 years). Additionally, Alternative B would include the use of three multi-season ice pads to store equipment through the summer to support ice road construction and other temporary construction activities. These would include:

- 10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024)
- 10.0-acre multi-season ice pad at the WOC (Q1 2021 to Q2 2022)
- 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik mine site (Q1 2021 to Q2 2022)

4.3.4.2 Camps

Table D.4.9 details camp requirements to support construction, drilling, and operations.

Table D.4.9. Alternative B Camps Summary

Project Phase	Camp	Location	Capacity	Use Schedule
Construction	Temporary	Ice pad near the Willow Operations Center	250	Q1 2021 to Q4 2021
Construction	Kuukpik Pad[a]	Kuukpik Pad[a]	450	Q1 2022 to Q2 2025
Construction	Alpine Operations[b]	Alpine processing facility (at Alpine CD1)[b]	250 to 300	Q1 2021 to Q2 2024
Construction	Temporary[c]	Willow Operations Center pad	100	Q1 2022 to Q4 2023
Construction	Sharktooth[b]	Kuparuk[a]	220	Q1 2022 to Q4 2023
Drilling	Drill rig camp(s)	Drill site(s) or Willow Operations Center pad	75	Q1 2023 to Q4 2032
Construction, operations	Willow Camp[c]	Willow Operations Center pad	500	Q4 2022 to Q4 2027
Operations	Willow Camp[c]	Willow Operations Center pad	200	Q1 2027 to Q4 2050

Note: Q1 (first quarter); Q2 (second quarter); Q4 (fourth quarter)
[a] Existing gravel pad.
[b] Existing camp.
[c] During construction, up to 60 bed spaces may be used at the existing Kuukpik Hotel in Nuiqsut in lieu of bed spaces identified at or near the Willow Operations Center.

Power generation and distribution, communications, potable water systems and use, domestic wastewater, solid waste, and drilling waste handling, as well as fuel and chemical storage, would be as described under Section 4.2.4, *Other Infrastructure and Utilities*.

4.3.5 Water Use

As described in Section 4.2.5, *Water Use*, freshwater would be needed during construction for domestic use at construction camps, construction and maintenance of ice roads and ice pads, and hydrostatic testing of pipelines. During drilling, freshwater would be required for domestic use at the drill rig camps and to support drilling activities. Water for construction and drilling would be withdrawn from lakes in the Project area. Freshwater for domestic use during operations would be sourced from Lakes M0015 and R0064 using the freshwater intake infrastructure (Section 4.2.4.5*, Potable Water*). Anticipated water use for Alternative B is detailed by year and Project phase in Table D.4.10. Seawater would also be required as described in Section 4.2.5, *Water Use*, and would be sourced from the Kuparuk STP and transported via seawater pipeline to the Project area (Section 4.2.2.3, *Other Import/Export Pipelines*).

Table D.4.10. Alternative B Estimated Freshwater Use by Project Phase and Year (million gallons)

Year (season)	Construction[a]	Drilling[b]	Operations[c]	Total
2020–2021 (winter)	194.7	0.0	0.0	194.7
2021 (summer)	1.5	0.0	0.0	1.5
2021–2022 (winter)	225.1	0.0	0.0	225.1
2022 (summer)	8.7	0.0	0.0	8.7
2022–2023 (winter)	179.4	6.7	0.0	186.1
2023 (summer)	12.2	13.4	0.0	25.6
2023–2024 (winter)	137.6	14.4	0.0	152.0
2024 (summer)	20.9	15.4	0.9	37.2
2024–2025 (winter)	118.7	21.0	1.8	141.5
2025 (summer)	2.7	26.7	3.3	32.7
2025–2026 (winter)	119.4	32.7	2.3	154.4
2026 (summer)	3.5	38.7	4.2	46.4
2026–2027 (winter)	14.8	38.7	3.2	56.7
2027 (summer)	3.9	38.7	5.1	47.7
2027–2028 (winter)	0.4	38.7	4.1	43.2
2028 (summer)	0.0	38.7	5.1	43.8
2028–2029 (winter)	0.0	38.7	4.1	42.8
2029 (summer)	0.0	38.7	5.1	43.8
2029–2030 (winter)	0.0	38.7	4.1	42.8
2030 (summer)	0.0	38.7	5.1	43.8
2030–2031 (winter)	0.0	38.7	4.1	42.8
2031 (summer)	0.0	38.7	5.1	43.8
2031–2032 (winter)	0.0	25.0	4.1	29.1
2032 (summer)	0.0	11.4	5.1	16.5
2032–2033+ (winter)	0.0	5.7	4.1	9.8
2033+ (summer)	0.0	0.0	5.1	5.1
Total	1,043.5	598.1	232.4	1,874.0

Note: "+" indicates annual use to the end of 2032 for drilling and the life of the Project (2050) for operations.
[a] Construction phase would include ice road construction (1.5 million gallons per mile for 35-foot-wide road and 3 million gallons per mile for 70-foot-wide road); ice pad construction (0.25 million gallons per acre); dust suppression; hydrostatic testing; and camp supply (100 gallons per person per day).
[b] Drilling phase would include drilling water (2 million gallons per well); and camp supply (100 gallons per person per day).
[c] Operations phase would include dust suppression and camp supply (100 gallons per person per day).

4.3.6 Gravel Requirements

Table D.4.11 lists the estimated quantity of gravel anticipated for each Project component.

Table D.4.11. Alternative B Estimated Gravel Requirements by Project Component

Component	Footprint (acres)[a]	Fill Quantity (cubic yards)[a]	Notes and Assumptions
Drill site pads (4 total)	58.0	712,000	Based on 4 drill sites with an average pad thickness of 9 feet and 2:1 side slopes
BT3/WPF pad	34.1	629,000	Based on an average pad thickness of 12 feet with 2:1 side slopes
Willow Operations Center pad	21.6	334,000	Based on an average pad thickness of 10 feet with 2:1 side slopes
Valve pads (4 total) and pipeline pads (4 total)	3.1	38,000	Based on 4 valve and 4 pipeline pads with an average pad thickness of 7 feet and 8 feet (respectively) with 2:1 side slopes
Water source access pads (2 total)	1.3	12,000	Based on 2 pads with an average pad thickness of 7 feet with 2:1 side slopes
Airstrip (includes airstrip and apron)	39.3	546,000	Based on an average pad thickness of 9.5 feet with 2:1 side slopes
Gravel roads	282.3	2,431,000	Based on an average road surface width of 24 to 32 feet and an average thickness of 7 feet with 2:1 side slopes; includes water source access and airstrip access and lighting access roads
Vehicle turnouts (8 total)	3.0	32,000	Eight subsistence tundra access road pullouts every 2.5 to 3.0 miles with an average thickness of 7 feet
Total[b]	442.7	4,734,000	NA

Note: 2:1 (2 horizontal to 1 vertical ratio); BT3 (drill site BT3); NA (not applicable); WPF (Willow processing facility)
[a] Values are approximate and are subject to change.
[b] Values may not total due to rounding.

4.3.7 Spill Prevention and Response

Spill prevention and response would be consistent with prevention measures and response procedures described in Section 4.2.8, *Spill Prevention and Response*. The WPF would provide a centralized facility to support Project drill sites in a variety of ways including equipment, personnel, and other support materials to respond to potential emergencies. Under Alternative B, CPAI would conduct regular ground-based visual inspections of facilities and pipelines, including the Willow Pipeline (oil export) and seawater pipeline from the WPF to GMT-2 from proposed gravel roads. The gravel road connection to the GMT development would also facilitate faster emergency response times to GMT-2 and GMT-1, as emergency response equipment at the Alternative B WPF would be closer to GMT-2 than the existing Alpine processing facility.

4.3.8 Schedule and Logistics

Detailed schedule and logistics information is provided in Section 4.2.10, *Schedule and Logistics*. Figure D.4.8 provides a general schedule for key construction, drilling, and operations milestones. Production from BT1, B3, and BT2 would begin in Q4 of 2024, Q2 of 2025, and Q4 of 2025, respectively. The schedule for production from BT4 could begin as early as Q4 of 2026 and from BT5 as early as Q4 of 2027. The schedule presented in Figure D.4.8 is based on the current best available information, and the schedule may be modified as detailed design progresses or as circumstances require.

4.3.9 Project Infrastructure in Special Areas

As described in Section 4.2.11, *Project Infrastructure in Special Areas*, Alternative B would include 1 mile of road (8.0 acres) and 1 mile of pipelines within the CRSA just southwest of GMT-2. Approximately 110 acres of the Project, including BT2 and BT4 and their associated roads, would be located within the TLSA. These designations allow for oil and gas development in these areas, and the Project would comply with BMPs associated with these two management areas (BLM 2008a, 2013).

4.3.10 Compliance with Best Management Practices

As described in Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*, Alternative B would require deviations from LS E-2 and five BMPs: E-5, E-7, E-11, K-1, and K-2. These include the location of the proposed road alignment within 1 mile of an observed yellow-billed loon nest and/or within 1,625 feet of a loon-nesting lake shoreline at lakes M0151, M0303, M1522, M1523A, M1523B, M1523C, M1524, R0066 and an unnamed lake near BT5. Alternative B would include a total of 12.4 miles of pipeline located within 500 feet of gravel roads (BMP E-7). This mileage is spread over several short road-pipeline stretches where separating roads from pipelines may not be feasible (e.g., within narrow land corridors between lakes, where roads converge on a drill site pad). CPAI would continue to seek opportunities to avoid pipeline placement within 500 feet of gravel roads as Project engineering progresses. These deviations from NPR-A BMPs are described in more detail in Table D.4.4 (Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*).

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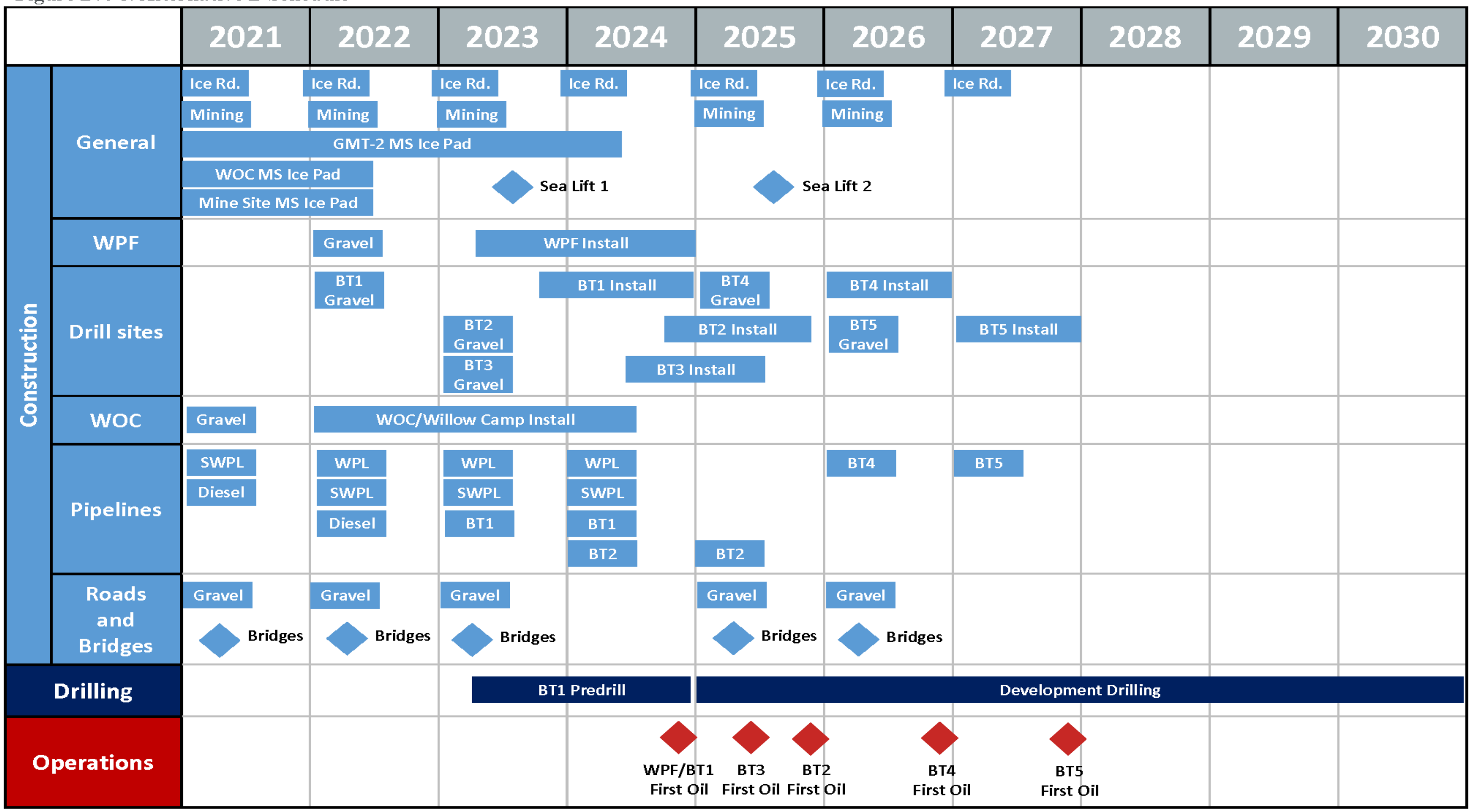
Figure D.4-8. Alternative B Schedule



Note: BT1/2/3/4/5 (Bear Tooth drill site BT1/2/3/4/5); GMT-2 (Greater Mooses Tooth 2); Ice Rd. (ice road); MS (multi-season); SWPL (seawater pipeline); WPF (Willow processing facility); WOC (Willow Operations Center); WPL (Willow pipeline). Sea Lift 1 includes WPF, BT1, BT2, and BT3 facilities; Sea Lift 2 includes BT4 and BT5 facilities; seawater and diesel pipeline horizontal directional drilling would occur in 2023.
Drilling would continue to 2032 based off 276 wells.
Operations would continue to end of the life of the field in 2050.

Appendix D Alternatives Development

Figure D.4.8. Alternative B Schedule

4.4 Alternative C: Disconnected Infield Roads

Alternative C would have the same gravel access road between GMT-2 and the Project area as Alternative B, but it would disconnect gravel road access between the WPF to BT1 (Figure D.4.2). Thus, there would be no gravel road between the two facilities or a bridge across Judy (Iqalliqpik) Creek; however, a gravel road would connect BT1 with BT2 and BT4, and additional support infrastructure. A second airstrip, storage and staging facilities, and camp would be located near BT2 to accommodate the movement of personnel and materials between the South WOC and the North WOC and BT1/BT2/BT4. A seasonal ice road would be constructed annually along the Alternative B gravel road alignment to allow for the movement of large equipment and consumable materials to BT1/BT2/BT4. Infield pipelines would connect all drill sites to the WPF; import and export pipelines would connect BT1/BT2/BT4 to the WPF and export/import lines would connect the WPF to existing infrastructure on the North Slope; and a diesel pipeline would extend from Kuparuk CPF2 to the South and North WOCs.

Under Alternative C, the WPF, South WOC, and primary Project airstrip would be located approximately 5 miles east of their location in Alternative B, near the GMT and Bear Tooth (BT) Unit boundary. Additionally, Alternative C (unlike Alternative B) would require a diesel pipeline connection from Alpine to the Project area due to the need to regularly supply fuel to the three disconnected drill sites; piped diesel fuel would also be available at the WPF and south and north WOCs.

Sealift module delivery to the Project area from either the Proponent's MTI or Point Lonely MTI would be required under Alternative C (Section 4.7, *Sealift Module Delivery Options*).

The intent of this alternative is to reduce effects to caribou movement and decrease the number of stream crossings required; this is also intended to further reduce impacts to subsistence users of these resources. This alternative would remove a portion of the road (versus Alternative B) that crosses Judy (Iqalliqpik) Creek, which could impede caribou movement across linear features (i.e., this alternative would avoid the junction of two roads, which could be a pinch point that deflects caribou movement). This alternative would also reduce linear infrastructure in the Project area, which would reduce some impacts to hydrology (e.g., sheet flow) and wetlands (e.g., direct fill, fugitive dust). The alternative would reduce summer ground traffic but would increase air traffic.

Table D.4.12 provides a summary of Project components and their associated impacts for Alternative C.

Table D.4.12. Summary of Components for Alternative C: Disconnected Infield Roads

Project Component	Description
Drill site gravel pads	Five 14.5-acre pads (72.5 acres total): BT1, BT2, BT3, BT4, and BT5
Willow processing facility gravel pad	22.1-acre pad located near the south airstrip
Willow Operations Center gravel pads	Two WOC pads (36.2 acres total): South WOC (21.6 acres) located near south airstrip North WOC (14.6 acres) located near north airstrip
Water source access gravel pads	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064
Other gravel pads	Four valve pads (1.7 acres total); 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing HDD Pipeline pads (2 total) at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre total) Pipeline crossing pad near GMT-2 (0.5 acre total)
Single season ice pads	Used during construction at the gravel mine site, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (903.6 total acres)
Multi-season ice pads	10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad at the South WOC (Q1 2021 to Q2 2022) 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2022)
Infield pipelines	56.1 total miles: BT1 to WPF (5.9 miles; not paralleled by gravel road); BT2 to BT1 (5.2 miles); BT4 to BT2 (9.4 miles); BT3 to WPF (5.7 miles); BT5 to WPF (10.8 miles); water source to South WOC (7.5 miles); and South WOC to North WOC (11.6 miles)

Project Component	Description
Willow export pipeline	31.2 total miles: WPF to tie-in pad near Alpine CD4N on new VSMs
Other pipelines	61.7-mile seawater pipeline from Kuparuk CPF2 to WPF on new VSMs shared with the diesel pipeline 68.9-mile diesel pipeline from Kuparuk CPF2 to Alpine processing facility at Alpine CD1 to South WOC on new VSMs (62.0 miles) and existing VSMs (6.8 miles)
Gravel roads	36.8 miles (273.5 acres, including vehicle turnouts) total connecting: BT5 and BT3 to the WPF, water source access to BT3, and WPF to South WOC, and South WOC to GMT-2 BT1, BT2, and BT4 to each other and the North WOC Seven vehicle turnouts with subsistence/tundra access ramps (2.6 acres total)
Bridges	Six total at Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 2, Willow Creek 4, Willow Creek 4A, Willow Creek 8
Airstrips	North airstrip and hangar: 5,600 × 200–foot airstrip and apron (39.3 acres); would also require airstrip access and lighting access roads South airstrip: 5,600 × 200–foot airstrip and plus apron (39.3 acres); would also require airstrip access and lighting access roads
Ice roads	Approximately 471.0 total miles (2,466.7 total acres): 393.0 miles (2,135.8 acres) over eight construction seasons (2021 to 2028) 3.9 miles (16.5 acres) of annual resupply ice road (2029 to 2050; 78.0 total miles; 330.9 total acres)
Total gravel footprint and gravel fill volume[a]	487.7 acres using 5.4 million cubic yards of gravel
Gravel source	Up to 230-acre site in Tiŋmiaqsiuġvik area
Total freshwater use	2,047.2 million gallons over the life of the Project (30 years)
Ground traffic (number of trips)[b, c]	2,340,368
Fixed-wing air traffic[b, d]	36,183 total flights South Willow: 29,096 North Willow: 5,838 Alpine: 1,249
Helicopter air traffic[b]	3,025 total flights South Willow: 2,327 North Willow: 572 Alpine: 126
Fish-bearing waterbody setback overlap (LS E-2)	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines
Less than 500-foot pipeline-road separation (BMP E-7)	11.0 miles of pipelines with less than 500 feet of separation
Yellow-billed loon setback overlap (BMP E-11)	39.8 acres of gravel infrastructure and 6.9 miles of pipelines within 1 miles of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests
River setback overlap (BMP K-1)	Colville River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.9 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 1.1 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines
Deepwater lake setback overlap (BMP K-2)	2.2 acres of gravel infrastructure and 0.2 mile of pipelines

Note: BMP (best management practice); BT1 (drill site BT1); BT2 (drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); GMT-2 (Greater Mooses Tooth 2); HDD (horizontal directional drilling); LS (lease stipulation); Q1 (first quarter); Q2 (second quarter); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)

[a] Values may not sum to totals due to rounding

[b] Total traffic for 30-year life of the Project (not including reclamation activity). Ground-traffic trips are one-way; a single flight is defined as a landing and subsequent takeoff.

[c] Total number of trips includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Construction ground traffic also includes gravel hauling (e.g., B70/maxi dump trucks).

[d] Flights outlined are additional flights required beyond projected travel to/from non-Project airstrips (e.g., Anchorage, Fairbanks, Deadhorse); includes C-130, Twin Otter/CASA, Cessna, and DC-6 or similar aircraft.

4.4.1 Project Facilities and Gravel Pads

Project facilities proposed for the WPF, drill sites, and WOCs for Alternative C are described in Section 4.2.1, *Project Facilities and Gravel Pads*. Additionally, this alternative would include a second WOC (north and south WOCs) to accommodate additional equipment storage, shop space, and camp serving BT1, BT2, and BT4 (Figure D.4.2). Under Alternative C, the WPF and (south) WOC would be located near the east end of the Project area along the BT-Unit and GMT-Unit boundary.

4.4.2 Pipelines

Alternative C pipelines (Figure D.4.9) would include infield pipelines connecting each drill site to the WPF and the Willow Pipeline (oil export) connecting the WPF to existing facilities at Alpine. Additional pipelines would include seawater import pipelines from Kuparuk CPF2 to the WPF and a diesel import pipeline from Kuparuk CPF2 to the South WOC. Alternative C would extend a diesel pipeline from the South WOC to the North WOC. A freshwater pipeline from the water source access pads would connect to the South WOC and also extend to the North WOC. Alternative C pipelines would place 32 total VSMs (typically 24-inch diameter) below OHW; all VSMs would be installed using the drill-set-slurry method. Pipeline design would be as described in Section 4.2.2, *Pipelines*.

Table D.4.13 summarizes pipeline infrastructure under Alternative C by pipeline segment.

Table D.4.13. Alternative C Pipeline Segments Summary

Pipeline Segment	Pipeline	Segment Length (miles)	Notes
BT4 to BT2 intersection	BT4 infield[a]	9.4	Pipelines on new VSMs
BT2 to BT1	BT2 infield[a]	5.2	Pipelines on new VSMs Would also transport BT4 materials
BT1 to WPF	BT1 infield[a]	5.9	Pipelines on new VSMs Would also transport BT4 and BT2 materials
BT3 to WPF	BT3 infield[a]	5.7	Pipelines on new VSMs; shares new VSMs with BT5 infield pipeline for 4.6 miles
BT5 to WPF	BT5 infield[a]	10.8	Pipelines on new VSMs; shares VSMs with BT3 infield pipeline for 4.6 miles
Water source to South WOC	Freshwater	7.5	Shares other new infield VSMs for 6.1 miles
South WOC to North WOC	Diesel Freshwater	11.6	Shares other infield VSMs for 11.2 miles
CPF2 to CD1 to South WOC	Diesel	68.9	Shares new VSMs with seawater and Willow export pipelines to CD4N and South WOC; shares existing VSMs from CD4N to CD1; shares new VSMs with seawater pipeline from CD4N to Kuparuk CPF2; includes new HDD crossing of the Colville river adjacent to the existing HDD crossing
WPF to CD4N tie-in pad	Willow export	31.2	Shares new VSMs with seawater and diesel pipelines
CPF2 to WPF	Seawater	61.7	Shares new VSMs with diesel pipelines; includes new HDD crossing of the Colville River adjacent to the existing HDD crossing

Note: BT1 (drill site BT1); BT2 (drill site BT2); BT4 (drill site BT4); BT5 (drill site BT5); CD1 (Alpine CD1); CD4N (Alpine CD4N); CPF2 (Kuparuk CPF2); GMT-2 (Greater Mooses Tooth 2); HDD (horizontal directional drilling); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)

[a] Infield pipelines include produced fluids, injection water, gas, and miscible-injectant pipelines.

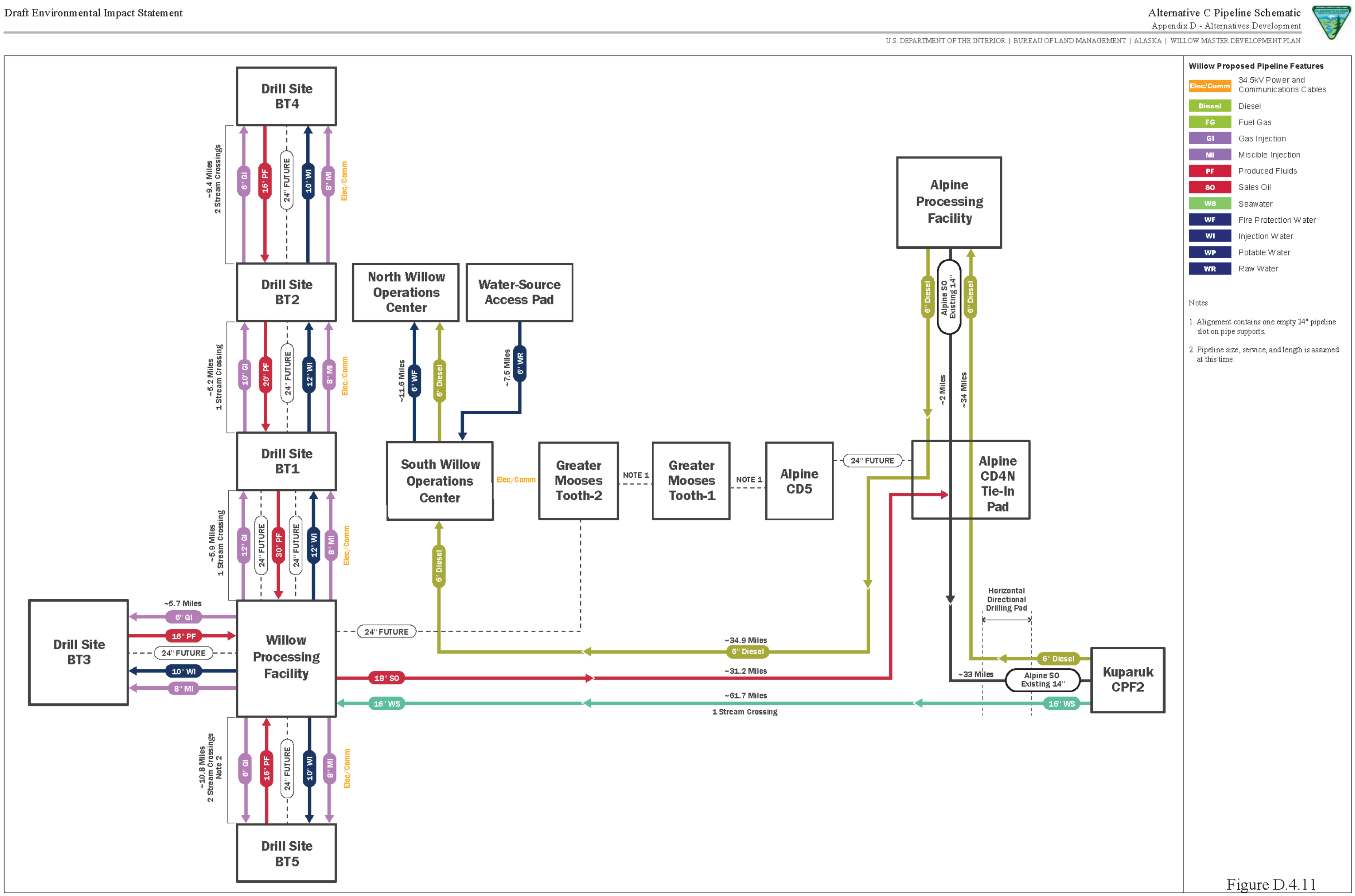


Figure D.4.9. Alternative C Pipeline Schematic

All pipelines would parallel gravel roads to facilitate routine visual observation and investigation of pipelines, except the roadless segment of the Project between the WPF and BT1. Conducting visual observation and investigation of pipelines from a gravel road would reduce the number, duration, and frequency of aircraft flights required to visually inspect pipelines. Without a road bridge at Judy (Iqalliqpik) Creek, the pipeline crossing would require a pipeline bridge with 18 VSMs placed below OHW. Although this segment would not be available for daily visual inspections, routine observations and investigation of pipelines would occur as part of CPAI's operational best practices, as well as to comply with regulatory requirements to conduct pipeline inspections. The absence of a parallel roadway would result in a greater number and frequency of aircraft operations to visually inspect pipelines. Alternative C would include two helicopter-accessible valve pads (1.1 acres total) at the pipeline crossing of Judy (Iqalliqpik) Creek.

From the WPF, the Willow Pipeline (oil export), seawater pipeline, and diesel pipeline would be located on a single set of new VSMs to Alpine CD4N; from Alpine CD4N to Kuparuk CPF2, the seawater and diesel pipelines would be placed on new VSMs, as described in Section 4.2.2, *Pipelines*. The diesel pipeline would be placed on existing VSMs from Alpine CD4N to the Alpine processing facility, located at Alpine CD1. In total, 336.5 miles of pipeline would be constructed with 329.7 miles of pipelines on new VSMs (approximately 98.0%) and 6.8 miles of pipelines on existing VSMs (approximately 2.0%) using 97.7 miles of new and existing pipeline corridors. Infield pipelines would connect each drill site to the WPF. Where practicable, infield pipelines would tie into other infield pipelines (Section 4.2.2.1, *Infield Pipelines*) to minimize redundant parallel pipelines.

4.4.3 Access to the Project Area

Alternative C would include seasonal ice road access to support construction; access to the WPF, BT3, BT1, and the South WOC via all-season gravel road from the GMT and Alpine developments; seasonal access (ice road) to BT1, BT2, BT4, and the North WOC; and helicopter and fixed-wing aircraft to the Project and Alpine airstrips. Table D.4.14 provides a summary of total traffic volumes anticipated for the Project under Alternative C by transportation type and year.

Table D.4.14. Alternative C Total Project Traffic Volumes for the Life of the Project

Year	Ground[a]	Fixed-Wing Trips Alpine[b]	Fixed-Wing Trips South Willow[b]	Fixed-Wing Trips North Willow[b]	Helicopter Trips Alpine[c]	Helicopter Trips South Willow[c]	Helicopter Trips North Willow[c]
2020	0	0	0	0	0	0	0
2021	112,210	252	0	0	63	50	50
2022	161,196	477	26	26	63	82	82
2023	229,101	52	566	383	0	120	25
2024	274,092	52	570	403	0	87	58
2025	155,776	52	1,058	728	0	80	53
2026	184,153	52	1,157	598	0	95	50
2027	172,174	52	1,158	404	0	103	42
2028 to 2032	419,578	260	5,558	1,185	0	382	64
2033 to 2050	632,088	0	19,003	2,111	0	1,328	148
Total	2,340,368	1,249	29,096	5,838	126	2,327	572

Note: Trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff.
[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks).
[b] Flights outlined are additional flights required beyond projected travel to/from non-project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.
[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection during all phases of the Project.

During construction, ice roads would be constructed to support Project pipeline, gravel pad and gravel road construction, and gravel source (Tiŋmiaqsiuġvik Mine Site) access over eight construction seasons. During drilling and operations, planned ice road use would be limited to drill rig mobilization and an annual resupply road connection to BT1, BT2, and BT4. (The Project would also use the annual resupply ice road between Alpine and Kuparuk. This ice road mileage is not included in the Project's analyses as it would be constructed regardless in support of the Alpine development.) Ice road design and mileage is described in Section 4.2.3.1, *Ice Roads*.

Gravel roads would provide year-round access between GMT and Alpine developments and the Project area, the WPF, South WOC, BT3, BT5, and the Project's potable water source. An additional gravel road would connect BT1, BT2, BT4, the North WOC, and the north airstrip with each other, but not the rest of the Project area. Alternative C gravel roads would require the construction of six bridges (Table D.4.15) following the design described in Section 4.2.3.2.1, *Bridges*. Four of the six bridges would require the placement of 36 total piles (ranging from 36- to 42-inch diameter below OHW). Alternative C would also require 10 additional culverts or culvert batteries at stream or swale crossings (Figure D.4.2) and 194 cross-drainage culverts.

Table D.4.15. Alternative C Bridges Summary

Waterbody Crossing	Bridge Length (± feet)[a]	Piles Below Ordinary High Water (number)	Latitude (North)	Longitude (West)
Judy (Kayyaaq) Creek	75	4	70.1848	152.1211
Fish (Uvlutuuq) Creek	500	24	70.2526	152.1787
Willow Creek 2	80	4	70.1413	151.9557
Willow Creek 4	130	4	70.0816	152.1302
Willow Creek 4A	50	0	70.0360	152.2015
Willow Creek 8	40	0	70.2635	152.1806

[a] Bridge lengths are approximations based on interpretation of available aerial imagery and are subject to change.

Under Alternative C, two airstrips would be constructed: the south airstrip would serve as the primary Project airstrip and would be located near the WPF and South WOC (at the boundary between the BT and GMT units); and the north airstrip which would be located near the North WOC and would provide year-round access to BT1, BT2, BT4, and the North WOC (Figure D.4.2).The south airstrip would be constructed in the winter construction season of 2021–2022; the north airstrip would be constructed in the winter construction season of 2021–2022. Prior to Project airstrip availability, the Alpine airstrip (located at Alpine CD1) would be used to support the Project.

Helicopters would be used during the Project's construction phase to support ice road construction, environmental monitoring, and surveying. Following the construction of gravel roads and during the drilling and operations phases, helicopter use to support the Project would primarily be limited to ongoing environmental monitoring and spill response support.

Sealift barges would be used to deliver processing and drill site modules to the North Slope via the MTI at Atigaru Point or Point Lonely (Section 4.7, *Sealift Module Delivery Options*). No additional or regular use of barges is proposed over the life of the Project.

4.4.4 Other Infrastructure

4.4.4.1 Ice Pads

Single- and multi-season ice pads would be used to support Project construction. Single-season and multi-season ice pads are described in Section 4.2.4.1, *Ice Pads*.

Alternative C would require 903.6 acres of single-season ice pads over the life of the Project (30 years). Additionally, Alternative C would include the use of three multi-season ice pads to support temporary camps and stage equipment and materials, as needed. The following multi-season ice pads are proposed under Alternative C:

- 10.0-acre multi-season ice pad GMT-2 (Q1 2021 to Q2 2024)
- 10.0-acre multi-season ice pad as South WOC (Q1 2021 to Q2 2022)
- 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2022)

4.4.4.2 Camps

Table D.4.16 details camp requirements for Alternative C to support construction, drilling, and operations.

Table D.4.16. Alternative C Camps Summary

Project Phase	Camp	Location	Capacity	Use Schedule
Construction	Temporary	Ice pad near the Willow Operations Center	250	Q1 2021 to Q4 2021
Construction	Kuukpik Pad[a]	Kuukpik Pad[a]	450	Q1 2022 to Q2 2025
Construction	Alpine Operations[b]	Alpine processing facility (at Alpine CD1)[b]	250 to 300	Q1 2021 to Q2 2024
Construction	Temporary[c]	South Willow Operations Center	100	Q1 2022 to Q4 2023
Construction	Sharktooth[b]	Kuparuk[a]	220	Q1 2022 to Q4 2023
Drilling	Drill rig camp(s)	Drill site(s) or Willow Operations Center (north and/or south)	75	Q1 2023 to Q4 2032
Construction, operations	South Willow Camp[c]	South Willow Operations Center	500	Q4 2022 to Q4 2027
Operations	South Willow Camp[c]	South Willow Operations Center	200	Q1 2027 to Q4 2050
Construction, drilling, operations	North Willow Camp	North Willow Operations Center	200	Q1 2022 to Q4 2050

Note: Q1 (first quarter); Q2 (second quarter); Q4 (fourth quarter)
[a] Existing gravel pad.
[b] Existing camp.
[c] During construction, up to 60 bed spaces may be used at the existing Kuukpik Hotel in Nuiqsut in lieu of bed spaces identified at or near the South Willow Operations Center.

Power generation and distribution, communications, potable water systems and use, domestic wastewater, solid waste, and drilling waste handling, as well as fuel and chemical storage, would be as described in Section 4.2.4, *Other Infrastructure and Utilities.*

4.4.5 Water Use

As described in Section 4.2.5, *Water Use*, freshwater would be needed during construction for domestic use at construction camps, construction and maintenance of ice roads and ice pads, and hydrostatic testing of pipelines. During drilling, freshwater would be required for domestic use at the drill rig camps and to support drilling activities. Water for construction and drilling would be withdrawn from lakes in the Project area. Freshwater for domestic use during operations would be sourced from Lakes M0015 and R0064 using the freshwater intake infrastructure (Section 4.2.4.5, *Potable Water*). Anticipated water use for Alternative C is detailed by year and Project phase in Table D.4.17. Seawater would also be required as described in Section 4.2.5, *Water Use*, and would be sourced from the Kuparuk STP and transported via seawater pipeline to the Project area (Section 4.2.2.3, *Other Import/Export Pipelines*).

Table D.4.17. Alternative C Estimated Freshwater Use Project Phase and Year (millions of gallons)

Year (season)	Construction[a]	Drilling[b]	Operations[c]	Total
2020–2021 (winter)	173.2	0.0	0.0	173.2
2021 (summer)	1.5	0.0	0.0	1.5
2021–2022 (winter)	219.7	0.0	0.0	219.7
2022 (summer)	9.1	0.0	0.0	9.1
2022–2023 (winter)	157.8	6.7	0.0	164.5
2023 (summer)	12.4	13.4	0.0	25.8
2023–2024 (winter)	215.7	14.4	0.0	230.1
2024 (summer)	19.9	15.4	0.9	36.2
2024–2025 (winter)	18.5	21.0	1.8	41.3
2025 (summer)	3.2	26.7	3.3	33.2
2025–2026 (winter)	100.7	32.7	2.3	135.7
2026 (summer)	2.6	38.7	4.2	45.5
2026–2027 (winter)	119.0	38.7	3.2	160.9
2027 (summer)	4.1	38.7	5.1	47.9
2027–2028 (winter)	15.2	38.7	4.1	58.0
2028 (summer)	1.1	38.7	5.1	44.9
2028–2029 (winter)	0.0	38.7	10.6	49.3
2029 (summer)	0.0	38.7	5.1	43.8
2029–2030 (winter)	0.0	38.7	10.6	49.3
2030 (summer)	0.0	38.7	5.1	43.8
2030–2031 (winter)	0.0	38.7	10.6	49.3
2031 (summer)	0.0	38.7	5.1	43.8
2031–2032 (winter)	0.0	25.0	10.6	35.6
2032 (summer)	0.0	11.4	5.1	16.5
2032–2033+ (winter)	0.0	5.7	10.6	16.3
2033+ (summer)	0.0	0.0	5.1	5.1
Total	1,073.7	598.1	375.4	2,047.2

Note: "+" indicates annual use to the end of 2032 for drilling and the life of the Project (2050) for operations.
[a] Construction phase would include ice road construction (1.5 million gallons per mile for 35-foot-wide road and 3 million gallons per mile for 70-foot-wide road); ice pad construction (0.25 million gallons per acre); dust suppression; hydrostatic testing; and camp supply (100 gallons per person per day).
[b] Drilling phase would include drilling water (2 million gallons per well); and camp supply (100 gallons per person per day).
[c] Operations phase would include dust suppression; camp supply (100 gallons per person per day); and an annual ice road (1.5 million gallons per mile for a 35-foot-wide road).

4.4.6 Gravel Requirements

Table D.4.18 lists the estimated quantity of gravel anticipated for each Project component under Alternative C.

Table D.4.18. Alternative C Estimated Gravel Requirements by Component

Component	Footprint (acres)[a]	Fill Quantity (cubic yards)[a]	Notes and Assumptions
Drill sites (5 total)	72.5	1,005,000	Based on 5 drill sites with an average pad thickness of 9 feet and 2:1 side slopes
Willow processing facility	22.1	338,00	Based on an average pad thickness of 10 feet with 2:1 side slopes
Willow Operations Center pads (2 total)	36.2	556,000	Based on 2 Willow Operations Centers with an average pad thickness of 10 feet with 2:1 side slopes
Valve pads (4 total) and pipeline pads (4 total)	3.5	42,000	Based on 4 valve pads and 4 pipeline pads with an average pad thickness of 7 feet and 8 feet (respectively) and 2:1 side slopes; Judy (Iqalliqpik) Creek pads would be sized to accommodate helicopter access
Water source access pads (2 total)	1.3	12,000	Based on 2 pads with an average pad thickness of 7 feet with 2:1 side slopes
Airstrips (2 total; includes aprons and airstrips)	78.6	1,092,000	Based on 2 airstrips with an average thickness of 9.5 feet with 2:1 side slopes
Gravel roads	270.9	2,329,000	Based on an average road surface width of 18 to 32 feet and thickness of 7 feet with 2:1 side slopes; includes water source access and airstrip access and lighting access roads
Vehicle turnouts (7 total)	2.6	28,000	Seven subsistence tundra access road pullouts every 2.5 to 3 miles with an average thickness of 7 feet
Total[b]	487.8	5,402,000	NA

Note: 2:1 (2 horizontal to 1 vertical ratio); NA (not applicable)
[a] Values are approximate and are subject to change.
[b] Values may not total due to rounding.

4.4.7 Spill Prevention and Response

Spill prevention and response would be consistent with prevention measures and response procedures described in Section 4.2.8, *Spill Prevention and Response*. The South WOC would provide a centralized facility to support Project drill sites (BT3 and BT5) and the WPF in a variety of spill response ways including housing equipment, personnel, and other support resources to respond to potential emergencies. Additional spill response equipment would be staged at the North WOC to address response requirements for BT1, BT2, and BT4, although this would require additional pad space to accommodate duplicated equipment. Additional response personnel could be transferred to the disconnected drill sites as needed via air should an accidental release occur outside of the ice-road season when the annual resupply route would not be in place.

Under Alternative C, CPAI would conduct regular ground based visual inspections of facilities and pipelines, including the seawater, diesel, and Willow export pipelines from the WPF to GMT-2 and from BT5 to the WPF from proposed gravel roads. For the cross-country portion of the pipelines without a parallel road between the Project access road and BT1, routine pipeline inspections and emergency response when the annual resupply ice road is not in place would be conducted using aircraft. Infield and import pipelines from BT1 to BT4 would be regularly inspected from the parallel gravel roadway.

The lack of a gravel road parallel to approximately 3.9 miles of infield, diesel, and seawater pipelines would not allow for routine daily observation of these pipelines to detect leaks or other problems that could result in a spill incident. Routine observation and investigation of pipelines would occur as part of CPAI's operational best practices, as well as in compliance with regulatory requirements to conduct pipeline inspections.

With the exception of the ice-road season, spill response mobilization to the roadless section of the Project would be limited to helicopters and low ground-pressure vehicles (e.g., Rolligons) traffic, both of which have limited cargo and/or passenger capacity. Response to a spill of any significant size would likely require multiple trips, further delaying response times. Additionally, helicopter response could be further limited by weather conditions. Summer travel by low ground-pressure vehicles during response may also result in additional tundra damage during transport when compared to a spill located near a road.

The gravel road connection to the GMT development may also facilitate faster emergency response times to GMT-2 and GMT-1 as emergency response equipment at the Alternative C WPF would be available in addition to the equipment staged at the existing Alpine processing facility. Under Alternative C, equipment staged at Willow would be available to provide mutual aid in the event of a fire, medical, or spill response at Alpine or Nuiqsut.

4.4.8 Schedule and Logistics

Detailed schedule and logistics information is provided in Section 4.2.10, *Schedule and Logistics*. Figure D.4.10 provides a general schedule for key construction, drilling, and operations milestones. Alternative C would require an additional year of gravel mining relative to Alternative B. Production from BT1, BT3, and BT2 would begin in Q4 of 2024, Q2 of 2025, and Q4 of 2025, respectively. The schedule for production from BT4 and BT5 would be delayed by one year relative to Alternative B: to Q4 of 2027 for BT4 and to Q4 of 2028 for BT5. The schedule presented in Figure D.4.10 is based on the current best available information and the schedule may be modified as detailed design progresses or as circumstances require.

4.4.9 Project Infrastructure in Special Areas

As described in Section 4.2.11, *Project Infrastructure in Special Areas*, Alternative C would include 1.0 mile of road (8.0 acres) and 1 mile of pipelines within the CRSA just southwest of GMT-2. Approximately 178 acres of the Project, including BT2 and BT4 and their associated roads and the North WOC and north airstrip, would be located within the TLSA. These designations allow for oil and gas development in these areas, and the Project would comply with BMPs associated with these two management areas (BLM 2008a, 2013).

4.4.10 Compliance with Best Management Practices

As described in Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*, Alternative C would require deviations from LS E-2 and five BMPs: E-5, E-7, E-11, K-1, and K-2. These include the locations of the proposed road alignment within 1 mile of an observed yellow-billed loon nest and/or within 1,625 feet of a loon-nesting lake shoreline at two lakes M0151 and an unnamed lake near BT5. Alternative C would include 11.0 miles of pipeline located within 500 feet of gravel roads (BMP E-7). This mileage is spread over several short road-pipeline sections where separating roads from pipelines may not be feasible (e.g., within narrow land corridors between lakes, where pipelines and roads converge on a drill site pad). CPAI will continue to seek opportunities to avoid placement of pipelines within 500 feet of roads as Project engineering progresses. Deviations anticipated for Alternative C are described in Table D.4.4 (Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*.)

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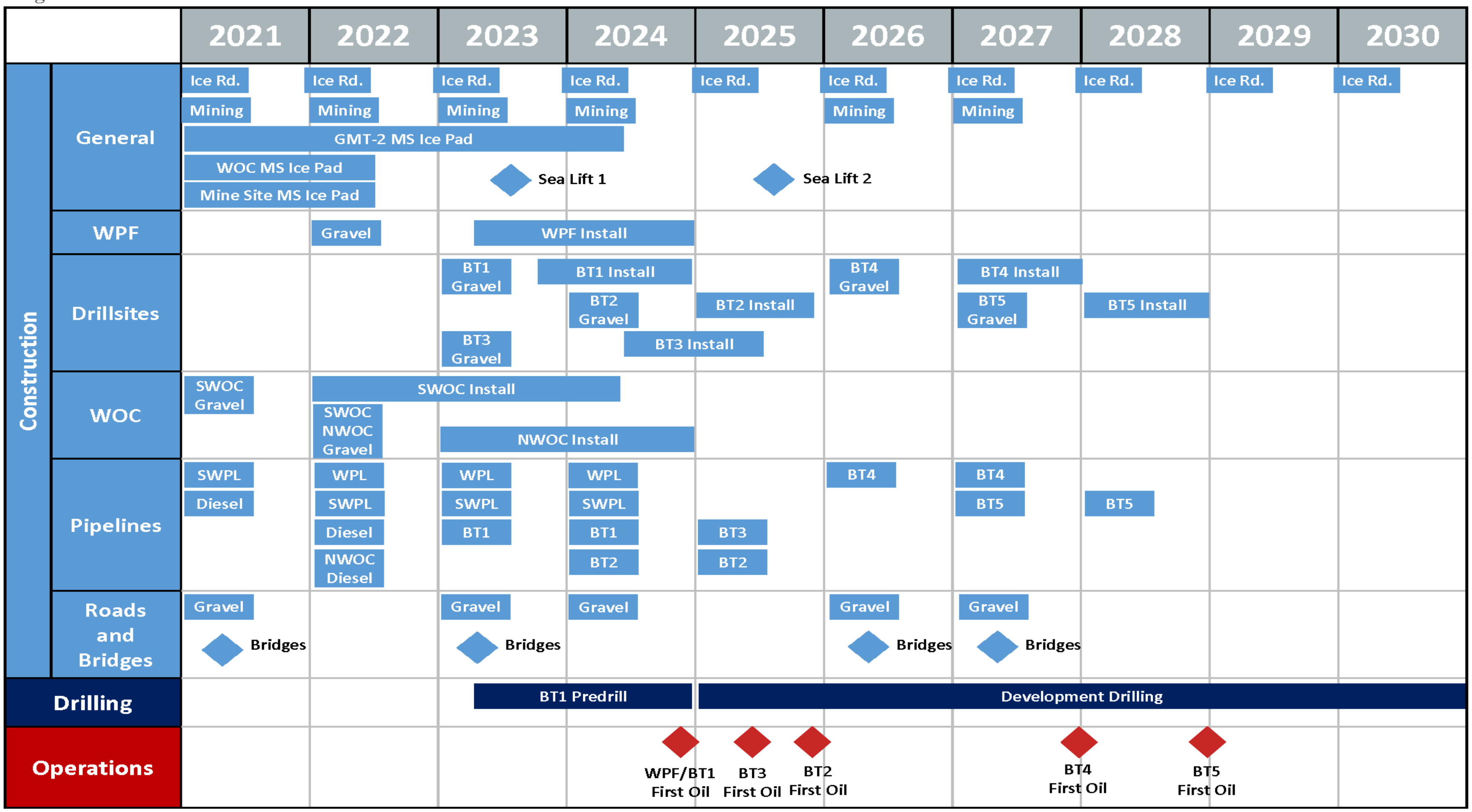
Figure D.4-10. Alternative C Schedule



Note: BT1/2/3/4/5 (Bear Tooth drill site BT1/2/3/4/5); GMT-2 (Greater Mooses Tooth 2); Ice Rd. (ice road); MS (multi-season); NWOC (North Willow Operations Center); SWOC (South Willow Operations Center); SWPL (seawater pipeline); WPF (Willow processing facility); WPL (Willow pipeline). Sea Lift 1 includes WPF, BT1, BT2, BT3 facilities; Sea Lift 2 includes BT4, BT5 facilities; seawater and diesel pipeline horizontal directional drilling would occur in 2023.
Drilling would continue to 2032 based off 276 wells.
Operations would continue to the end of the life of the field in 2050.

Figure D.4.10. Alternative C Schedule

4.5 Alternative D: Disconnected Access

Alternative D would colocate the WPF with BT3 (like Alternative B), construct four additional drill sites, WOC, pipeline and valve pads, water source access road and pads, gravel roads connecting the drill sites to the WPF/BT3, and an airstrip. However, Alternative D would not be connected by an all-season gravel access road to the GMT and Alpine developments (Figure D.4.3); but, it would employ the other gravel roads as proposed under Alternative B connecting drill sites and other Project infrastructure. Annual resupply access to the Project area would be provided by ice road connection between GMT-2 and the WPF (9.8 miles).

The lack of a gravel access road connection to Alpine would reduce the degree to which the Project could leverage existing Alpine infrastructure. As a result, additional facilities would be required in the Project area, duplicating some facilities currently at Alpine, including warehouse space; valve and fleet shops; emergency response equipment; biocide, methanol, and corrosion inhibitor storage tanks; and an incinerator. The addition of these facilities in the Project area would require additional gravel pad space at the WOC and WPF. Additionally, Alternative D would require a diesel pipeline connection from Kuparuk CPF2 to the WOC (similar to Alternative C) as fuel could not be trucked to the Project area throughout the year.

Alternative D would require sealift module delivery to the Project area from either the Proponent's MTI or Point Lonely MTI (Section 4.7, *Sealift Module Delivery Options*).

The intent of Alternative D is to reduce the number of bridges, minimize the length of linear infrastructure on the landscape, and provide another strategy to decrease effects to caribou movement and subsistence. Additionally, this alternative would have the smallest overall gravel footprint, which would reduce impacts to hydrology (e.g., sheet flow) and wetlands (e.g., direct fill, indirect impacts from dust). The alternative would reduce ground traffic in summer but would increase air traffic.

Table D.4.19 provides a summary of Project components and their associated impacts for Alternative D.

Table D.4.19. Summary of Components for Alternative D: Disconnected Access

Project Component	Description
Drill site gravel pads	Four (14.5-acre pads; 58.0 acres total): BT1, BT2, BT4, BT5 (BT3 would be colocated with the WPF)
Willow processing facility gravel pad	WPF colocated with BT3; 59.5-acre pad
Willow Operations Center gravel pad	237.6-acre pad located near BT3/WPF and airstrip
Water source access gravel pads	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064
Other gravel pads	Four valve pads (1.3 acres total): 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing HDD pipeline pads (2) at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre total) Pipeline crossing pad near GMT-2 (0.5 acre total)
Single-season ice pads	Used during construction at the gravel mine, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (982.6 total acres)
Multi-season ice pads	10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad at the WOC (Q1 2021 to Q2 2022); 4.2 acres would later be covered by gravel fill 10.0-acre multi-season ice pad at Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2023)
Infield pipelines	31.0 total miles: BT1 to WPF (7.2 miles); BT2 to BT1 (5.2 miles); BT4 to BT2 (9.4 miles); BT5 to WPF (7.0 miles); water source to WOC (2.2 miles)
Willow export pipeline	36.4 total miles: WPF to tie-in pad near Alpine CD4N with 9.8 miles of pipeline not paralleled by gravel road

Project Component	Description
Other pipelines	66.9-mile seawater pipeline from Kuparuk CPF2 to WPF; on new VSMs shared with the diesel pipeline 72.8-mile diesel pipeline from Kuparuk CPF2 to Alpine processing facility at drill site CD1 to WOC on new VSMs (66.0 miles); on existing VSMs between Alpine CD4N and Alpine CD1 (6.8 miles)
Gravel roads	28.3 miles (211.9 acres including turnouts) total connecting BT5 to BT3/WPF, WPF to GMT-2, airstrip access, airstrip lighting, and water source access roads, and BT1, BT2, and BT4; there would be no gravel road connection to GMT-2 Six turnouts with subsistence/tundra access ramps (2.2 acres total)
Bridges	Six total at Judy (Iqalliqpik) Creek, Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 4, Willow Creek 4A, and Willow Creek 8
Airstrip	5,600 × 200–foot airstrip and apron (39.3 acres total); would also require airstrip access and lighting access roads
Ice roads	Approximately 694.5 total miles (3,442.8 total acres): 469.1 miles (2,486.6 acres) over nine construction seasons (2021 to 2029) 225.4 miles (956.2 acres) of resupply ice road (2030 to 2052)
Total gravel footprint and gravel fill volume[a]	371.4 acres using 5.2 million cubic yards of gravel
Gravel source	Tiŋmiaqsiuġvik Mine Site (up to 230 acres)
Total freshwater use	2,433.8 million gallons over the life of the Project (32 years)
Ground traffic (number of trips)[b, c]	3,187,363
Fixed-wing air traffic[b, d]	45,398 total flights Willow: 41,967 Alpine: 3,431
Helicopter air traffic[b]	4,658 total flights Willow: 4,476 Alpine: 182
Fish-bearing waterbody setback overlap (LS E-2)	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines
Less than 500-foot pipeline separation (BMP E-7)	9.4 miles of pipelines and road with less than 500 feet of separation
Yellow-billed loon setback overlap (BMP E-11)	56.7 acres of gravel infrastructure and 6.9 miles of pipelines within 1 mile of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests
River setback overlap (BMP K-1)	Colville River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.6 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 16.7 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines
Deepwater lake setback overlap (BMP K-2)	2.2 miles of gravel infrastructure and 0.2 mile of pipelines

Note: BMP (best management practice); BT1 (drill site BT1); BT2 (drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); GMT-2 (Greater Mooses Tooth 2); HDD (horizontal directional drilling); LS (lease stipulation); Q1 (first quarter); Q2 (second quarter); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)
[a] Values may not sum to totals due to rounding.
[b] Total traffic for 32-year life of the Project (not including reclamation activity). Ground-traffic trips are one-way; a single flight is defined as a landing and subsequent takeoff.
[c] Number of trips includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Construction ground traffic also includes gravel hauling (e.g., B70/maxi dump trucks).
[d] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse); includes C-130, Twin Otter/CASA, Cessna, and DC-6 or similar aircraft.

4.5.1 Project Facilities and Gravel Pads

Project facilities proposed for the WPF, drill sites, and WOC for Alternative D are described in Section 4.2.1, *Project Facilities and Gravel Pads*. Under Alternative D, the WPF and BT3 would be colocated and in the same location as provided under Alternative B.

4.5.2 Pipelines

Alternative D pipelines (Figure D.4.11) would include infield pipelines connecting each drill site to the WPF and the Willow Pipeline (oil export) connecting the WPF to existing facilities at Alpine. Additional new pipelines would include a seawater import pipeline from Kuparuk CPF2 to the WPF, a diesel import pipeline from Kuparuk CPF2 to the WPF, and a freshwater pipeline from the water source access pads to the WOC.

Alternative C pipelines would place 14 total VSMs (typically 24-inch diameter) below OHW; all VSMs would be installed using the drill-set-slurry method. Pipeline design would be as described in Section 4.2.2, *Pipelines*.

Table D.4.20 summarizes pipeline infrastructure under Alternative D by pipeline segment.

Table D.4.20. Alternative D Pipeline Segments Summary

Pipeline Segment	Pipeline	Segment Length (miles)	Notes
BT4 to BT2 intersection	BT4 infield[a]	9.4	Pipelines on new VSMs
BT2 to BT1	BT2 infield[a]	5.2	Pipelines on new VSMs Would also transport BT4 materials
BT1 to WPF	BT1 infield[a]	7.2	Pipelines on new VSMs Would also transport BT4 and BT2 materials
BT5 to WPF	BT5 infield[a]	7.0	Pipelines on new VSMs
Water source to WOC	Freshwater	2.2	Pipeline share BT5 infield VSMs for 0.8 mile
BT3/WPF to CD4N tie-in	Willow export	36.4	Would share new VSMs with seawater and diesel pipelines
BT3/WPF to CPF2	Seawater	66.9	Would share new VSMs with Willow export and diesel pipelines; includes new HDD crossing of Colville River adjacent to existing HDD crossing
WOC to CD4N to CD1 to CPF2	Diesel	72.8	Would share new VSMs with Willow export and seawater pipelines from the WOC to Alpine CD4N; would share existing VSM from Alpine CD4N to Alpine CD1; would share new VSMs with seawater from Alpine CD4N to Kuparuk CPF2; includes new HDD crossing of Colville River adjacent to existing HDD crossing.

Note: BT1 (drill site BT1); BT2 (drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); CD1 (Alpine CD1); CD4N (Alpine CD4N); CPF2 (Kuparuk CPF2); HDD (horizontal directional drilling); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)
[a] Infield pipelines include produced fluids, injection water, gas, and miscible-injectant pipelines.

From the BT3/WPF to a tie-in pad near Alpine CD4N, the Willow Pipeline (oil export) would share a new set of VSMs with the seawater and diesel pipelines. From the BT3/WPF to Kuparuk CPF2, the seawater pipeline would share new VSMs with the Willow and diesel pipelines; a new HDD crossing of the Colville River would be adjacent to the existing HDD crossing site. From the WOC to Alpine CD4N, the diesel pipeline would share new VSMs with the Willow export and seawater pipelines; from Alpine CD4N to Alpine CD1, the diesel pipeline would be placed on existing VSMs; and from Alpine CD4N to Kuparuk CPF2, the diesel pipeline would be on new VSMs shared with the seawater pipeline. The diesel pipeline would also include an HDD crossing of the Colville River adjacent to the existing HDD crossing. Where practicable, infield pipelines would tie in to other infield pipelines (Section 4.2.2.1, *Infield Pipelines*) to minimize redundant, parallel pipelines.

In total, 293.8 miles of pipelines would be constructed with 287.0 miles of pipelines on new VSMs (approximately 97.7%) and 6.8 miles of pipelines on existing VSMs (approximately 2.3%) using 95.6 miles of new and existing pipeline corridors.

All pipelines would parallel gravel roads to facilitate routine visual observation and investigation of pipelines, where practicable. Conducting visual observation and investigation of pipelines from a gravel road would reduce the number and frequency of aircraft flights required to visually inspect pipelines. Export and import pipelines would not parallel gravel roads from approximately the airstrip to GMT-2, (10 miles), where no gravel road would be present. Although this pipeline segment would not be available for daily visual inspections, routine observations and investigation of pipelines would occur as part of CPAI's operational best practices, as well as to comply with regulatory requirements to conduct pipeline inspections. The absence of a parallel roadway would result in a greater number and frequency of aircraft operations to visually inspect pipelines.

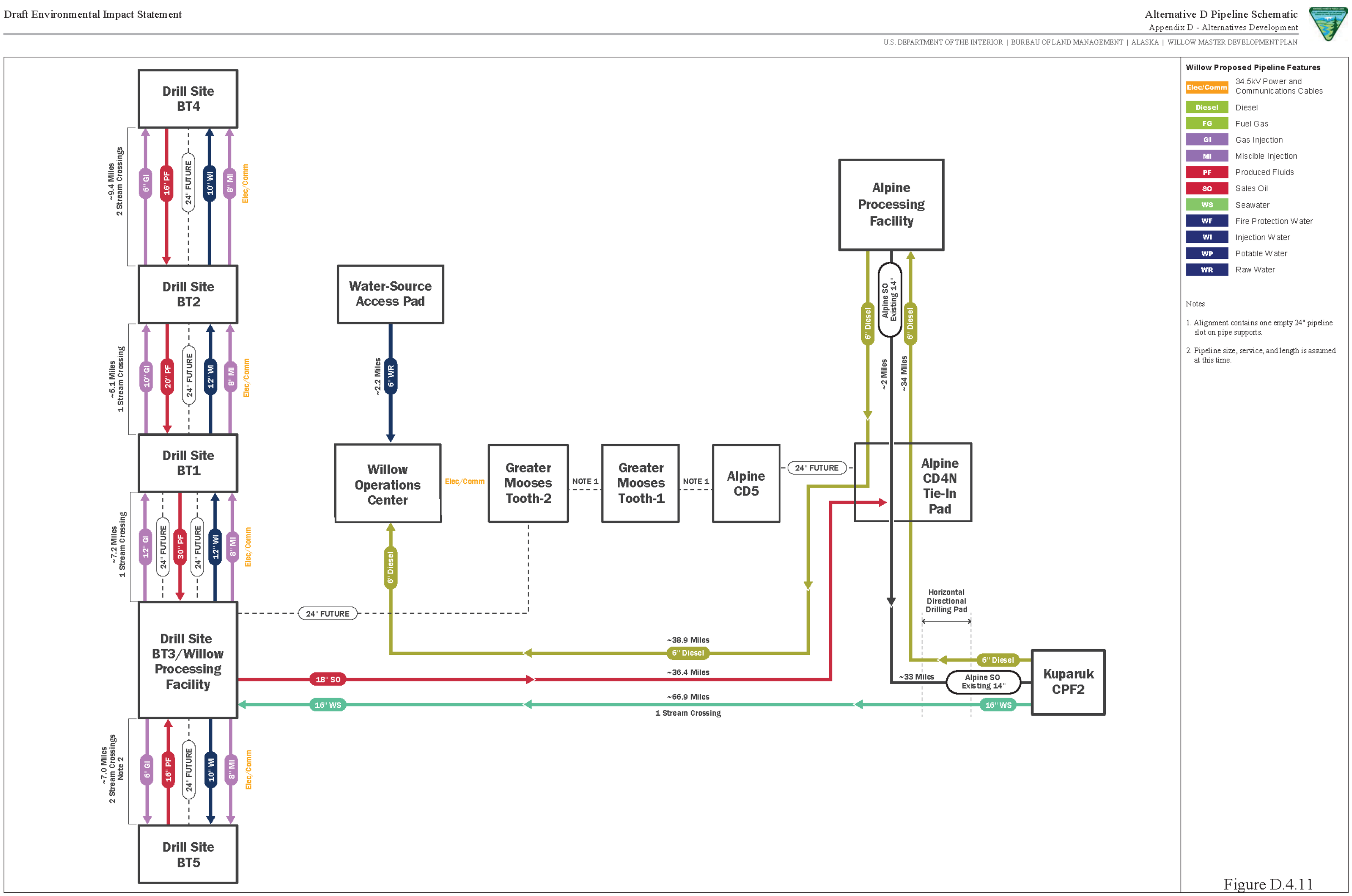


Figure D.4.11. Alternative D Pipeline Schematic

4.5.3 Access to the Project Area

Alternative D would include seasonal ice road access between the Project area and GMT-2 to support construction and annual Project resupply; access from BT3/WPF to individual drill sites via all-season gravel roads; helicopter and fixed-wing aircraft to the Project and Alpine airstrips; and ice road connection to either the Proponent's MTI or Point Lonely MTI during construction. Table D.4.21 provides a summary of total anticipated traffic volumes for the Project under Alternative D by transportation type and year.

Table D.4.21. Alternative D Total Project Traffic Volumes for the Life of the Project

Year	Ground[a]	Fixed-Wing Trips Alpine[b]	Fixed-Wing Trips Willow[b]	Helicopter Trips Alpine[c]	Helicopter Trips Willow[c]
2020	0	0	0	50	0
2021	92,610	120	0	50	0
2022	163,828	503	0	82	0
2023	172,396	0	788	0	82
2024	176,605	72	1,172	0	82
2025	187,896	144	1,214	0	154
2026	207,909	144	2,076	0	154
2027	239,535	144	2,076	0	154
2028 to 2034	971,146	1,008	12,231	0	1,078
2035 to 2052	975,438	1,296	22,410	0	2,772
Total	3,187,363	3,431	39,503	182	4,476

Note: Trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff.
[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks).
[b] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.
[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection during all phases of the Project.

The increase in ground traffic under Alternative D (versus Alternatives B and C) is primarily due construction and drilling sequencing. Under Alternative D, construction activities would occur over 2 additional years (relative to Alternative B; 1 year longer than Alternative C), resulting in an increase in construction traffic across the entire construction phase. Similarly, the delay in the start of drilling would extend the drilling phase and result in increased traffic to support the drilling phase overall.

During construction, ice roads would be constructed to support Project pipeline, gravel pad and gravel road construction, and gravel source (Tiŋmiaqsiuġvik Mine Site) access over nine winter construction seasons. During drilling and operations, an annual resupply ice road would be constructed between GMT-2 and the Project's gravel infrastructure (following the same alignment as the gravel road under Alternative B). Additional limited ice roads would be constructed as needed to accommodate drill rig mobilization. Ice road design and mileage is described in Section 4.2.3.1, *Ice Roads*.

Alternative B gravel roads would require the construction of six bridges (Table D.4.22) following the design described in Section 4.2.3.2.1, *Bridges*. Four of the six bridges would require the placement of 52 total piles (ranging from 36- to 42-inch diameter) below OHW. Alternative D would also require eight additional culverts or culvert batteries at stream or swale crossings (Figure D.4.3) and 149 cross-drainage culverts.

Table D.4.22. Alternative D Bridges Summary

Waterbody Crossing	Bridge Length (± feet)[a]	Piles Below Ordinary High Water (number)	Latitude (North)	Longitude (West)
Judy (Iqalliqpik) Creek	420	20	70.1462	152.0914
Judy (Kayyaaq) Creek	75	4	70.1848	152.1211
Fish (Uvlutuuq) Creek	500	24	70.2526	152.1787
Willow Creek 4	130	4	70.0816	152.1302
Willow Creek 4A	50	0	70.0360	152.2015
Willow Creek 8	40	0	70.2635	152.1806

[a] Bridge lengths are approximations based on interpretation of available aerial imagery and are subject to change.

The airstrip would be constructed during the winter construction season of 2021–2022 and located near the WOC (Section 4.2.3.3, *Airstrip and Associated Facilities*). Prior to airstrip availability, the Alpine airstrip (located at Alpine CD1) may be used to support the Project. Helicopters would be used during Project construction to support ice road construction, environmental monitoring, and surveying. Following the construction of gravel roads and during the drilling and operations phases, helicopters used to support the Project would primarily be limited to ongoing environmental monitoring and spill response support.

Sealift barges would be used to deliver processing and drill site modules to the North Slope via the MTI at Atigaru Point or Point Lonely (Section 4.7, *Sealift Module Delivery Options*). No additional or regular use of barges is proposed over the life of the Project.

4.5.4 Other Infrastructure

4.5.4.1 Ice Pads

Single- and multi-season ice pads would be used to support Project construction. Single-season and multi-season ice pads are described in Section 4.2.4.1, *Ice Pads*.

Alternative D would require 982.6 acres of single-season ice pads over the life of the Project (30 years). Additionally, Alternative D would include the use of three multi-season ice pads to support temporary camps and stage equipment and materials, as needed. The following multi-season ice pads are proposed under Alternative C:

- 10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024)
- 10.0-acre multi-season ice pad at the Willow Operations Center (Q1 2021 to Q2 2022); 4.2 acres would later be covered by gravel infrastructure
- 10.0-acre multi-season ice pad at Tiŋmiaqsiuġvik mine site (Q1 2021 to Q2 2023)

4.5.4.2 Camps

Table D.4.23 details camp requirements for Alternative D to support Project construction, drilling, and operations.

Table D.4.23. Alternative D Camps Summary

Project Phase	Camp	Location	Capacity	Use Schedule
Construction	Temporary	Ice pad near Willow Operations Center	250	Q1 2021 to Q4 2022
Construction	Kuukpik Pad[a]	Kuukpik Pad[a]	150	Q1 2021 to Q2 2030
Construction	Alpine Operations[b]	Alpine processing facility (at Alpine CD1)[b]	250	Q1 2021 to Q4 2024
Construction	Temporary[c]	Willow Operations Center	100	Q1 2022 to Q4 2026
Construction	Sharktooth[b]	Kuparuk[a]	220	Q1 2022 to Q4 2023
Drilling	Drill rig camp(s)	Drill site(s) or Willow Operations Center	75	Q1 2024 to Q4 2034
Construction, operations	Willow Camp[c]	Willow Operations Center	500	Q4 2022 to Q4 2029
Operations	Willow Camp[c]	Willow Operations Center	200	Q1 2029 to Q4 2052

Note: Q1 (first quarter); Q2 (second quarter); Q4 (fourth quarter)
[a] Existing gravel pad.
[b] Existing camp.
[c] During construction, up to 60 bed spaces may be used at the existing Kuukpik Hotel in Nuiqsut in lieu of bed spaces identified at or near the Willow Operations Center.

4.5.5 Water Use

As described in Section 4.2.5, *Water Use*, freshwater would be needed during construction for domestic use at construction camps, construction and maintenance of ice roads and ice pads, and hydrostatic testing of pipelines. During drilling, freshwater would be required for domestic use at the drill rig camps and to support drilling activities. Water for construction and drilling would be withdrawn from lakes in the Project area. Freshwater for domestic use during operations would be sourced from Lakes M0015 and R0064 using the freshwater intake infrastructure (Section 4.2.4.5, *Potable Water*). Anticipated water use for Alternative D is detailed by year and Project phase in Table D.4.24. Seawater would also be required as described in Section 4.2.5, *Water Use*, and would be sourced from the Kuparuk STP and transported via seawater pipeline (Section 4.2.2.3, *Other Import/Export Pipelines*).

Table D.4.24. Alternative D Estimated Freshwater Use by Project Phase and Year (million gallons)

Year (season)	Construction[a]	Drilling[b]	Operations[c]	Total
2020–2021 (winter)	229.8	0.0	0.0	229.8
2021 (summer)	1.4	0.0	0.0	1.4
2021–2022 (winter)	260.5	0.0	0.0	260.5
2022 (summer)	8.8	0.0	0.0	8.8
2022–2023 (winter)	175.5	0.0	0.0	175.5
2023 (summer)	8.4	0.0	0.0	8.4
2023–2024 (winter)	126.8	6.7	0.0	133.5
2024 (summer)	6.9	13.4	0.0	20.3
2024–2025 (winter)	40.5	14.4	0.0	54.9
2025 (summer)	15.1	15.4	3.3	33.8
2025–2026 (winter)	27.3	20.4	2.3	50.0
2026 (summer)	1.3	25.4	4.2	30.9
2026–2027 (winter)	125.7	32.0	3.2	160.9
2027 (summer)	5.3	38.7	5.1	49.1
2027–2028 (winter)	140.2	38.7	4.1	183.0
2028 (summer)	3.2	38.7	5.1	47.0
2028–2029 (winter)	31.0	38.7	4.1	73.8
2029 (summer)	2.0	38.7	5.1	45.8
2029–2030 (winter)	0.2	38.7	20.4	59.3
2030 (summer)	0.0	38.7	5.1	43.8
2030–2031 (winter)	0.0	32.7	20.4	53.1
2031 (summer)	0.0	26.7	5.1	31.8
2031–2032 (winter)	0.0	26.7	20.4	47.1
2032 (summer)	0.0	26.7	5.1	31.8
2032/2033 (Winter)	0.0	26.7	20.4	47.1
2033 (Summer)	0.0	26.7	5.1	31.8
2033/2034 (Winter)	0.0	19.0	20.4	39.4
2034 (Summer)	0.0	11.4	5.1	16.5
2034/2035+ (Winter)	0.0	5.7	20.4	26.1
2035+ (Summer)	0.0	0.0	5.1	5.1
Total	1,209.9	600.9	623.0	2,433.8

Note: "+" indicates annual use to the end of 2034 for drilling or the life of the Project (2052) for operations.
[a] Construction phase would include ice road construction (1.5 million gallons per mile for 35-foot-wide road and 3 million gallons per mile for 70-foot-wide road); ice pad construction (0.25 million gallons per acre); dust suppression; hydrostatic testing; and camp supply (100 gallons per person per day).
[b] Drilling phase would include drilling water (2 million gallons per well); and camp supply (100 gallons per person per day).
[c] Operations phase would include dust suppression; camp supply (100 gallons per person per day); and an annual ice road (1.5 million gallons per mile for a 35-foot-wide road).

4.5.6 Gravel Requirements

Table D.4.25 lists the estimated quantity of gravel anticipated for each Project component under Alternative D.

Table D.4.25. Alternative D Estimated Gravel Requirements by Component

Component	Footprint (acres)[a]	Fill Quantity (cubic yards)[a]	Notes and Assumptions
Drill sites (4 total)	58.0	804,000	Based on 4 drill sites with an average pad thickness of 9 feet and 2:1 side slopes
BT3/WPF	59.5	1,240,000	Based on an average pad thickness of 13.5 feet with 2:1 side slopes
Willow Operations Center	37.6	700,000	Based on an average pad thickness of 12 feet with 2:1 side slopes
Valve pads (4 total) and pipeline pads (4 total)	3.1	38,000	Based on 4 valve pads and 4 pipeline pads with an average pad thickness of 7 feet and 8 feet (respectively) with 2:1 side slopes
Water source access pads (2 total)	1.3	12,000	Based on 2 pads with an average pad thickness of 7 feet with 2:1 side slopes
Airstrip (includes airstrip and apron)	39.3	546,000	Based on an average pad thickness of 9.5 feet with 2:1 side slopes
Gravel roads	209.7	1,806,000	Based on average road surface width of 18 to 32 feet and thickness of 7 feet with 2:1 side slopes; includes 1.3-mile water source access and airstrip access and lighting access roads
Vehicle turnouts (6 total)	2.2	24,000	Eight 0.3-acre subsistence tundra access road pullouts every 2.5 to 3 miles
Total[b]	410.7	5,170,000	NA

Note: 2:1 (2 horizontal to 1 vertical ratio); BT3/WPF (drill site BT3/Willow processing facility); NA (not applicable)
[a] Values are approximate and are subject to change.
[b] Values may not total due to rounding.

4.5.7 Spill Prevention and Response

Spill prevention and response would be consistent with prevention measures and response procedures described in Section 4.2.8, *Spill Prevention and Response*. The WPF would provide a centralized facility to support Project drill sites, including equipment, personnel and other support to respond to potential emergencies. The lack of an all-season gravel road connection to the GMT and Alpine developments would pose additional challenges to for spill response during the non-ice road season.

The lack of a gravel road parallel to approximately 10 miles of Willow export, diesel, and seawater pipelines would not allow for routine daily observation of these pipelines to detect leaks or other problems that could result in a spill incident. Routine observation and investigation of pipelines would occur as part of CPAI's operational best practices, as well as in compliance with regulatory requirements to conduct pipeline inspections.

Without an all-season gravel access road connection to GMT-2, existing emergency response equipment at Alpine would need to be duplicated at Willow, requiring additional gravel pad space. Construction of the Project would also provide no additional benefits for emergency response to any incidents that could occur at GMT-2 and other facilities within the Alpine development, and equipment at Willow would not be available to provide mutual aid in the event of a fire, medical, or spill response at Alpine or in Nuiqsut.

With the exception of the ice road season, spill response mobilization would be limited to helicopters and low ground-pressure vehicles (e.g., Rolligons) traffic, both of which have limited cargo and/or passenger capacity. Response to a spill of any significant size would likely require multiple trips, further delaying response times. Additionally, helicopter response could be further limited by weather conditions. Summer travel by low ground-pressure vehicles during response may also result in additional tundra damage during transport when compared to a spill located near a road.

Substantial truck traffic by ice road over the life of the Project would pose additional health, safety, and environmental hazards, as vehicles unintentionally leaving the roadway is more likely to occur on ice roads than gravel roads. This poses additional risk to Project personnel and increases the risk of minor spills associated with vehicle accidents.

4.5.8 Schedule and Logistics

Detailed schedule and logistics information is provided in Section 4.2.10, *Schedule and Logistics*.

The lack of a gravel access road connection under Alternative D would result in less flexibility to leverage existing infrastructure and would result in less efficient construction in comparison to Alternatives B and C. The lack of flexibility would result in additional constraints on development construction and logistics that would extend the construction phase compared to Alternatives B and C by 1 and 2 years, respectively and delay first oil by approximately 1.5 years (Q1 of 2026).

To help mitigate these logistical issues, initial construction activities would prioritize construction of the WOC, delaying construction of the WPF and BT1 until 2024 (versus 2023 Alternatives B and C). Until construction of the diesel pipeline from Kuparuk CPF2 to the Project area is completed, the transport of diesel fuel would also be a limiting factor in construction logistics. This would specifically limit the opportunity to conduct early well pre-drilling and delay first oil production to Q1 of 2026 (versus Alternatives B and C, where first oil production would begin in Q4 of 2024).

Figure D.4.12 provides a general schedule for key construction, drilling, and operations milestones. The schedule presented in Figure D.4.12 is based on the current best available information; the schedule may be modified as detailed design progresses and as circumstances require.

4.5.9 Project Infrastructure in Special Areas

As described in Section 4.2.11, *Project Infrastructure in Special Areas*, Alternative D would include 1 mile of pipelines within the CRSA just southwest of GMT-2. Approximately 110 acres of the Project, including BT2 and BT4 and their associated roads, would be located within the TLSA. These designations do allow oil and gas development in these areas, and the Project would comply with BMPs associated with these two management areas (BLM 2008a, 2013).

4.5.10 Compliance with Best Management Practices

As described in Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*, Alternative D would require deviations from LS E-2 and four BMPs: E-5, E-11, K-1, and K-2. These include the location of the proposed road alignment within 1 mile of an observed yellow-billed loon nest and/or within 1,625 feet of a loon-nesting lake shoreline at lakes M0303, M1522, M1523A, M1523B, M1523C, M1524, and an unnamed lake near BT5. Alternative D would include 9.4 miles of pipeline located within 500 feet of gravel roads (BMP E-7). This mileage is spread over several short road-pipeline stretches where separating roads from pipelines may not be feasible (e.g., within narrow land corridors between lakes, where pipelines and roads converge on a drill site pad). CPAI will continue to seek opportunities to avoid placement of pipelines within 500 feet of roads as Project engineering progresses. Other deviations for Alternative D are described in Table D.4.4 (Section 4.2.12, *Compliance with Bureau of Land Management Stipulations, Best Management Practices, and Supplemental Practices*).

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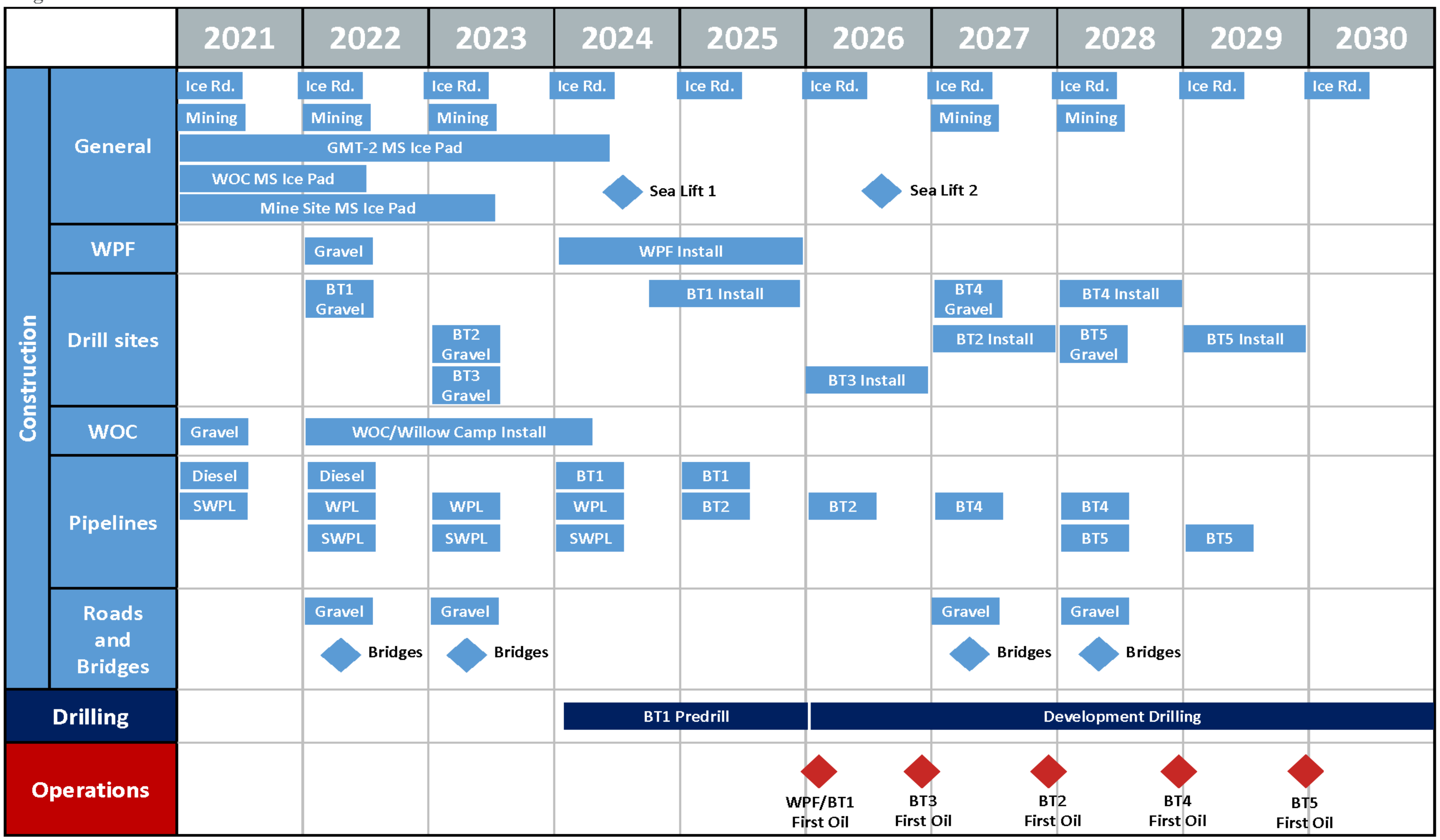
Figure D.4-12. Alternative D Schedule



Note: BT1/2/3/4/5 (Bear Tooth drill site BT1/2/3/4/5); GMT-2 (Greater Mooses Tooth 2); Ice Rd. (ice road); MS (multi-season); SWPL (seawater pipeline); WPF (Willow processing facility); WOC (Willow Operations Center); WPL (Willow pipeline). Sea Lift 1 includes WPF, BT1, BT2, BT3 facilities; Sea Lift 2 includes BT4, BT5 facilities; Seawater and diesel pipeline horizontal directional drilling would occur in 2023.
Drilling would continue to 2034 based on 276 wells.
Operations would continue to the end of the life of the field in 2052.

Appendix D Alternatives Development

Figure D.4.12. Alternative D Schedule

4.6 Comparison of Action Alternatives

Table D.4.26 provides a summary comparison of impacts by action alternative. Figure D.4.13 provides a comparison of the action alternatives.

Table D.4.26. Summary Comparison of Impacts by Action Alternatives

Project Component	Alternative B – Proponent's Project	Alternative C – Disconnected Infield Roads	Alternative D – Disconnected Access
Drill site gravel pads	Four 14.5-acre pads (58.0 acres total): BT1, BT2, BT4, and BT5 (BT3 would be colocated with the WPF)	Five 14.5-acre pads (72.5 acres total): BT1, BT2, BT3, BT4, and BT5	Four 14.5-acre pads (58.0 acres total): BT1, BT2, BT4, and BT5 (BT3 would be colocated with the WPF)
Willow processing facility gravel pad	WPF colocated with BT3; 34.1-acre pad	22.1-acre pad located near the south airstrip	WPF colocated with BT3; 59.5-acre pad
Willow Operations Center gravel pad	21.6-acre pad located near BT3/WPF and airstrip	Two WOC pads (36.2 acres total): South WOC (21.6 acres) located near south airstrip North WOC (14.6 acres) located near north airstrip	37.6-acre pad located near BT3/WPF and airstrip
Water source access gravel pads	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064	Two water source access pads (1.3 acres total) at Lakes M0015 and R0064
Other gravel pads	Four valve pads (1.3 acres total); 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing Two HDD pipeline pads at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre) Pipeline crossing pad near GMT-2 (0.5 acre)	Four valve pads (1.7 acres total); 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing Two HDD pipeline pads at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre) Pipeline crossing pad near GMT-2 (0.5 acre)	Four valve pads (1.3 acres total): 2 pads at Judy (Iqalliqpik) Creek pipeline crossing and 2 pads at Fish (Uvlutuuq) Creek pipeline crossing Two HDD pipeline pads at Colville River crossing (1.1 acres total) Tie-in pad near Alpine CD4N (0.2 acre) Pipeline crossing pad near GMT-2 (0.5 acre)
Single-season ice pads	Used during construction at the gravel mine site, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (767.6 total acres)	Used during construction at the gravel mine site, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (903.6 total acres)	Used during construction at the gravel mine, bridge crossings, the Colville River HDD crossing, and other locations as needed in the Project area (982.6 total acres)
Multi-season ice pads	30.0 acres total 10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad at WOC (Q1 2021 to Q2 2022) 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2022)	30.0 acres total 10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad at the South WOC (Q1 2021 to Q2 2022) 10.0-acre multi-season ice pad at the Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2022)	25.8 acres total 10.0-acre multi-season ice pad at GMT-2 (Q1 2021 to Q2 2024) 10.0-acre multi-season ice pad at the WOC (Q1 2021 to Q2 2022); 4.2 acres would later be covered by gravel infrastructure 10.0-acre multi-season ice pad at Tiŋmiaqsiuġvik Mine Site (Q1 2021 to Q2 2023)

Project Component	Alternative B – Proponent's Project	Alternative C – Disconnected Infield Roads	Alternative D – Disconnected Access
Infield pipelines	31.6 total segment miles: BT1 to WPF (7.3 miles) BT2 to BT1 (5.2 miles) BT4 to BT2 (9.4 miles) BT5 to WPF (7.5 miles) Water source to WOC (2.2 miles)	56.1 total segment miles: BT1 to WPF (5.9 miles) BT2 to BT1 (5.2 miles) BT3 to WPF (5.7 miles) BT4 to BT2 (9.4 miles) BT5 to WPF (10.8 miles) Water source to South WOC (7.5 miles) Water source (South WOC) to North WOC (11.6 miles)	31.0 total segment miles: BT1 to WPF (7.2 miles) BT2 to BT1 (5.2 miles) BT4 to BT2 (9.4 miles) BT5 to WPF (7.0 miles) Water source to WOC (2.2 miles)
Willow export pipeline	36.5 total miles on new VSMs (WPF to tie-in pad near Alpine CD4N)	31.2 total miles on new VSMs (WPF to tie-in pad near Alpine CD4N)	36.4 total miles on new VSMs (WPF to tie-in pad near Alpine CD4N); 9.7 miles of pipeline not paralleled by gravel road
Other pipelines	67.1-mile seawater pipeline from Kuparuk CPF2 to WPF on new VSMs 34.0-mile diesel pipeline from Kuparuk CPF2 to Alpine CD4N on new VSMs (30.9 miles) and CD4N to the Alpine processing facility at Alpine CD1 on existing VSMs (3.1 miles)	61.7-mile seawater pipeline from Kuparuk CPF2 to WPF on new VSMs 68.9-mile diesel pipeline from Kuparuk CPF2 to Alpine processing facility at Alpine CD1 to South WOC on existing VSMs (6.8 miles) and new VSMs (62.1 miles); 11.6 miles from South WOC to North WOC on new, shared VSMs	66.9-mile seawater pipeline from Kuparuk CPF2 to WPF; on new VSMs 72.8-mile diesel pipeline from Kuparuk CPF2 to Alpine processing facility at Alpine CD1 to WOC on existing VSMs (6.8 miles) and new VSMs (66.0 miles)
Pipeline VSMs below ordinary high water (number)	14 total: 4 at Judy (Kayyaaq) Creek 4 at Willow Creek 2 6 at Willow Creek 4	32 total: 18 at Judy (Iqalliqpik) Creek 4 at Judy (Kayyaaq) Creek 4 at Willow Creek 2 6 at Willow Creek 4	14 total: 4 at Judy (Kayyaaq) Creek 4 at Willow Creek 2 6 at Willow Creek 4
Gravel roads	38.2 miles (285.3 total acres, including turnouts) total connecting drill sites to the WPF, WPF to GMT-2, water source access to WOC, and airstrip access and lighting access roads Eight turnouts with subsistence/tundra access ramps (3.0 acres total)	36.8 miles (273.5 total acres, including turnouts) total connecting: BT5 and BT3 to the WPF, water source access to BT3, WPF to South WOC, South WOC to GMT-2, and airstrip access and lighting access roads BT1, BT2, and BT4 to each other and the North WOC, and north airstrip access and lighting access roads Seven vehicle turnouts with subsistence/tundra access ramps (2.6 acres total)	28.3 miles (211.9 total acres, including turnouts) total connecting BT5 to BT3/WPF; water source access to WOC; BT1, BT2, and BT4 to WOC; and airstrip access and lighting access roads; no gravel road connection to GMT-2 Six turnouts with subsistence/tundra access ramps (2.2 acres total)

Project Component	Alternative B – Proponent's Project	Alternative C – Disconnected Infield Roads	Alternative D – Disconnected Access
Bridges	Seven total bridges: Judy (Iqalliqpik) Creek, Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 2, Willow Creek 4, Willow Creek 4A, and Willow Creek 8	Six total bridges: Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 2, Willow Creek 4, Willow Creek 4A, Willow Creek 8	Six total bridges: Judy (Iqalliqpik) Creek, Judy (Kayyaaq) Creek, Fish (Uvlutuuq) Creek, Willow Creek 4, Willow Creek 4A, and Willow Creek 8
Bridge piles below ordinary high water (number)	56 total: 20 at Judy (Iqalliqpik) Creek 4 at Judy (Kayyaaq) Creek 24 at Fish (Uvlutuuq) Creek 4 at Willow Creek 2 4 at Willow Creek 4	36 total: 4 at Judy (Kayyaaq) Creek 24 at Fish (Uvlutuuq) Creek 4 at Willow Creek 2 4 at Willow Creek 4	52 total: 20 at Judy (Iqalliqpik) Creek 4 at Judy (Kayyaaq) Creek 24 at Fish (Uvlutuuq) Creek 4 at Willow Creek 4
Culverts or culvert batteries (number)	11	10	8
Cross-drainage culverts (number)	202	194	149
Airstrip	5,600 × 200–foot airstrip and apron (39.3 acres total); would also require airstrip access and lighting access roads	North airstrip: 5,600 × 200–foot airstrip and hangar (39.3 acres total); would also require airstrip access and lighting access roads South airstrip: 5,600 × 200–foot airstrip and apron (39.3 acres total); would require airstrip access and lighting access roads	5,600 × 200–foot airstrip and apron (39.3 acres total); would also require airstrip access and lighting access roads
Ice roads	Approximately 372.0 total miles (2,074.7 total acres) over seven construction seasons (2021 to 2028)	Approximately 471.0 total miles (2,466.7 total acres) 393.0 miles (2,135.8 acres) over eight construction seasons (2021 to 2029) 3.9 miles (16.5 acres) of annual resupply ice road (2029 to 2050; 78.0 total miles; 330.9 total acres)	Approximately 694.5 total miles (3,442.8 total acres) 478.9 miles (2,528.1 acres) over nine construction seasons (2021 to 2030) 9.8 miles (41.6 acres) of annual resupply ice road (2030 to 2052; 215.6 total miles; 914.7 total acres)
Total gravel footprint and gravel fill volume[a]	442.7 acres using 4.7 million cubic yards of gravel	487.8 acres using 5.4 million cubic yards of gravel	410.7 acres using 5.2 million cubic yards of gravel
Gravel source	Up to 230-acre site in Tiŋmiaqsiuġvik area	Up to 230-acre site in Tiŋmiaqsiuġvik area	Up to 230-acre site in Tiŋmiaqsiuġvik area
Total freshwater use	1,874.0 million gallons over the life of the Project (30 years)	2,047.2 million gallons over the life of the Project (30 years)	2,433.8 million gallons over the life of the Project (32 years)
Ground traffic (number of trips)[b, c]	3,009,933	2,340,368	3,187,363
Fixed-wing air traffic[b, d]	35,713 total flights Willow: 34,464 Alpine: 1,249	36,183 total flights South Willow: 29,096 North Willow: 5,838 Alpine: 1,249	45,398 total flights Willow: 41,967 Alpine: 3,431

Project Component	Alternative B – Proponent's Project	Alternative C – Disconnected Infield Roads	Alternative D – Disconnected Access
Helicopter air traffic[b]	2,478 total flights Willow: 2,337 Alpine: 141	3,025 total flights South Willow: 2,327 North Willow: 572 Alpine: 126	4,658 total flights Willow: 4,476 Alpine: 182
Project duration	30 years (7 years of construction)	30 years (8 years of construction)	32 years (9 years of construction)
Fish-bearing waterbody setback overlap (LS E-2)	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines	1.9 acres of gravel footprint, 0.1 mile of gravel road, and 1.8 miles of pipelines
Less than 500-foot pipeline-road separation (BMP E-7)	12.4 miles of pipelines and road with less than 500 feet of separation	11.0 miles of pipelines and road with less than 500 feet of separation	9.4 miles of pipelines and roads with less than 500 feet of separation
Yellow-billed loon setback overlap (BMP E-11)	56.7 acres of gravel infrastructure and 6.9 miles of pipelines within 1 mile of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests	39.8 acres of gravel infrastructure and 6.9 miles of pipelines within 1 mile of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests	56.7 acres of gravel infrastructure and 6.9 miles of pipelines within 1 mile of a nest 3.9 acres of gravel infrastructure and 3.3 miles of pipelines within 1,625 feet of lakes with nests
River setback overlap (BMP K-1)	Colville River: 0.0acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.6 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 16.7 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines	Colville River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.9 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 1.1 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines	Colville River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines Fish (Uvlutuuq) Creek: 11.6 acres of gravel infrastructure and 5.4 miles of pipelines Judy (Iqalliqpik) Creek: 16.7 acres of gravel infrastructure and 2.3 miles of pipelines Ublutuoch (Tiŋmiaqsiuġvik) River: 0.0 acres of gravel infrastructure and 0.0 miles of pipelines
Deepwater lake setback overlap (BMP K-2)	2.2 acres of gravel infrastructure and 0.2 mile of pipelines	2.2 acres of gravel infrastructure and 0.2 mile of pipelines	2.2 acres of gravel infrastructure and 0.2 mile of pipelines

Note: BMP (best management practice); BT1 (drill site BT1); BT2 (drill site BT2); BT3 (drill site BT3); BT4 (drill site BT4); BT5 (drill site BT5); CD1 (Alpine CD1); CD4N (Alpine CD4N); GMT-2 (Greater Mooses Tooth 2); LS (lease stipulation); MTI (module transfer island); VSM (vertical support member); WPF (Willow processing facility); WOC (Willow Operations Center)

[a] Values may not sum to totals due to rounding

[b] Total traffic is for the life of the Project (Alternative B and C, 30 years; Alternative D 32 years) and does not include any reclamation activity. Ground-traffic trips are one-way; a single flight is defined as a landing and subsequent takeoff; and a single vessel trip is defined as docking and subsequent departure

[c] Number of trips includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Construction ground traffic also includes gravel hauling (e.g., B70/maxi dump trucks).

[d] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse); includes C-130, Twin Otter/CASA, Cessna, and DC-6 or similar aircraft.

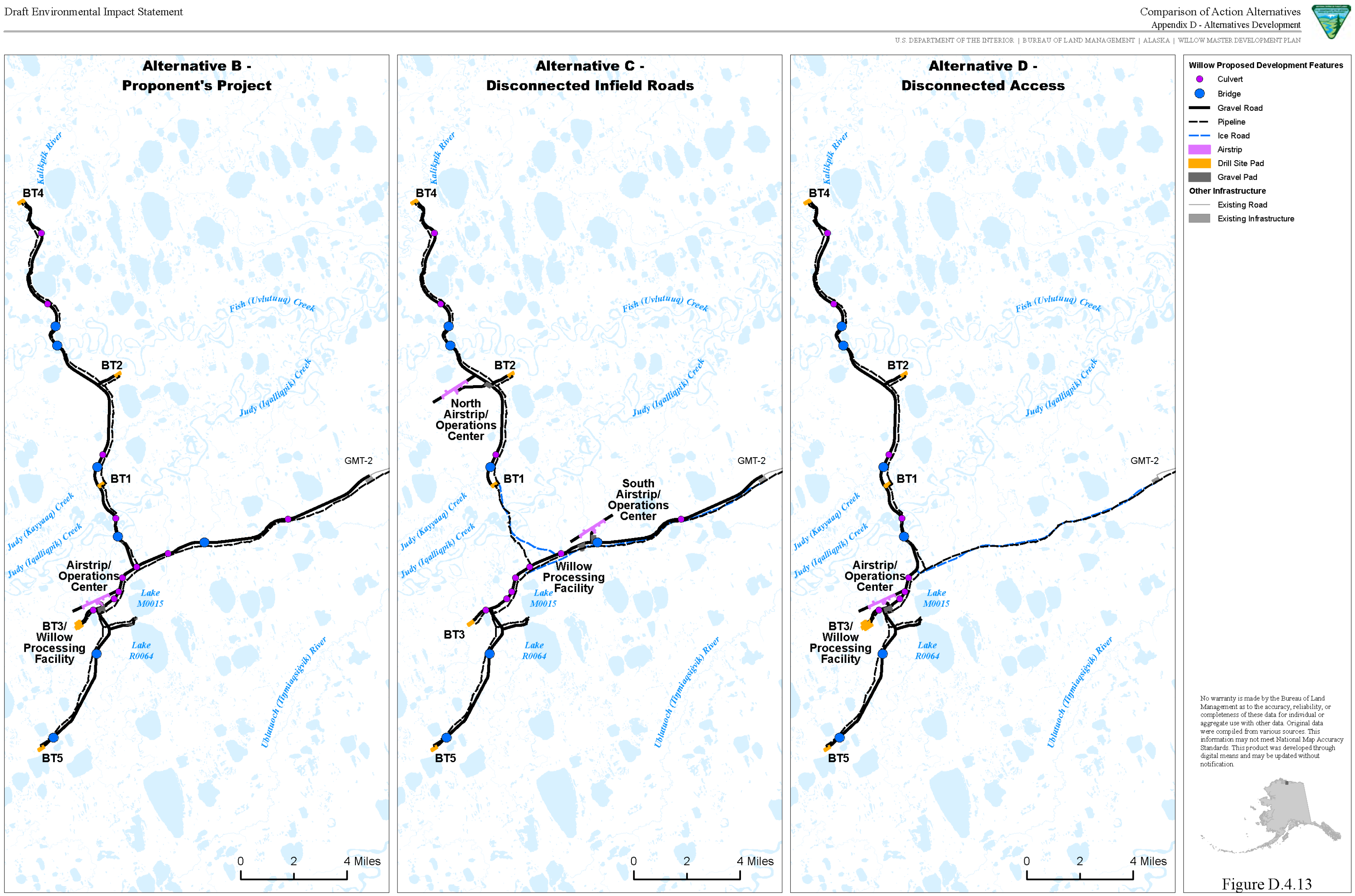


Figure D.4.13. Comparison of Action Alternatives

4.7 Sealift Module Delivery Options

CPAI proposes to use pre-fabricated modules for Project components like the WPF and drill site facilities. These large modules would be fabricated at an off-site location and transported to North Slope via sealift barge. Modules for the WPF are anticipated to weigh between 3,000 and 4,000 tons; sealift barges average 400 feet long by 100 feet wide by 25 feet deep (USACE 2012, Appendix G). To facilitate off-loading and mobilization to the Project area, two module delivery options are presented for detailed analysis:

- Option 1: Proponent's Module Transfer Island
- Option 2: Point Lonely Module Transfer Island

Any of the module delivery options could be combined with any of the action alternatives.

4.7.1 Option 1: Proponent's Module Transfer Island

Option 1 is BLM's preferred module delivery option. The identification of a preferred module delivery option does not constitute a commitment or decision; if warranted, BLM may select a different module delivery option than the preferred module delivery option in its Record of Decision.

4.7.1.1 Module Transfer Island Construction

CPAI has proposed construction of an MTI with a design life of 5 to 10 years in Harrison Bay near Atigaru Point to support sealift module delivery for the Project. Modules for the WPF, BT1, BT2, and BT3 would be delivered by sealift barges to the MTI during the summer of 2023 (Alternatives B and C) or 2024 (Alternative D). A second sealift would deliver modules for BT4 and BT5 in 2025 (Alternatives B and C) or 2026 (Alternative D). Modules would be stored on the MTI and mobilized from the MTI to the WPF via ice road the following year.

The MTI would be built through placement of gravel fill from the Tiŋmiaqsiuġvik area gravel mine in approximately 8 to 10 feet of water to a height of approximately 13 feet above mean lower low water (MLLW). The MTI would include a 600-foot-square (8.3-acre) gravel work surface surrounded by 3 horizontal to 1 vertical (3:1) side slopes with gravel bag armor slope protection and a 200-foot-long sheet pile dock with a top surface at 16 feet above MLLW to facilitate barge offloading (Figure D.4.4). The resulting island footprint would be approximately 12.8 acres (based on an assumed 8.5-foot depth) on the seafloor.

Gravel haul and placement to construct the MTI would occur via an ice road during the 2021–2022 winter construction season under Alternatives B and C and the 2023–2024 winter season under Alternative D, as soon as the ice roads have been constructed. Winter MTI construction would occur from a grounded sea ice pad surrounding the MTI. Sea ice within the MTI footprint, surrounding the MTI footprint, and the associated sea-ice road would be bottom-fast (frozen to the seafloor) before construction of the MTI would begin. Sea ice within the MTI footprint would be cut, and gravel would be placed into the opening until the design volume and approximate shape of the MTI is attained. Installation of the sheet-pile offload dock would occur once the initial gravel placement is sufficient to support pile-driving activities and staging of materials and equipment. Sheet pile would be installed over approximately 25 to 30 days, with approximately 3 to 6 hours of actual pile driving occurring per day, using vibratory driving equipment. After completion of the sheet-pile bulkhead, 24-inch diameter pipe pile would be installed to support the dock face and provide barge mooring, using both vibratory and impact pile-driving equipment. Installation of the pipe pile would take approximately 2 days with approximately 2 hours of pile driving per day (estimated at 1.5 hours of vibratory driving and 0.5 hour of impact driving per day). Winter pile driving for dock construction would cease prior to sea ice breakup. Because the MTI footprint and sea ice immediately surrounding the MTI would be bottom-fast, construction activities and materials would be unlikely to contact liquid seawater under the ice.

On-site equipment and facilities to support winter construction would include an office, break room, envirovac, an emergency camp, mobile light plants, helipad, navigational aids, and a tripwire perimeter alarm and surveillance camera. An approximately 120-foot-tall communications tower would be erected at the start of MTI construction and would remain in place until after the first module delivery season is complete; the tower would be reinstalled for the second module delivery season and remain in place until MTI decommissioning. One additional tower (i.e., repeater) would be erected on a multi-season ice pad to relay communications signals to the Project area. On-site facilities would also include a fuel storage area to hold and store multiple fuel tanks filled via ice road to support MTI construction. Workers to support winter construction would be housed at a 100-person construction camp located on an ice pad near Atigaru Point (Figure D.4.4). Except for equipment needed for summer construction activities, equipment would be removed from the MTI at the end of the winter construction season and transported via ice road to designated onshore staging areas.

During the following summer's open water season (2022 for Alternatives B and C and 2023 for Alternative D), construction equipment would be transported to the MTI by barge, likely from Oliktok Point. Workers to support summer construction would be housed at a 100-person camp located on a barge moored at or near the MTI. Work on the MTI would recommence around early to mid-July once the risk of ice encroachment has passed. The gravel surface would be reworked and compacted to eliminate interstitial ice and then graded to the final design. Large, pre-fabricated filter fabric panels would be installed on the side slopes by crane, and slope protection, in the form of 4-cubic-yard gravel-filled bags, would be installed on the fabric-covered side slopes from the seafloor to the work surface. All construction equipment not needed for subsequent activities on the MTI would be demobilized as soon as summer construction activities are completed.

4.7.1.2 Module Delivery

Prior to the sealift barge arrival, an 850- by 250-foot area (4.9 acres) in front of the dock face would be **screeded** to prepare for barge off-loading. (Screeding is a process that recontours sediment on the marine floor but does not remove sediment from the water and would be used to provide a smooth and flat seafloor surface for the barges to rest on during off-loading.) Modules would be offloaded from five sealift barges onto the MTI in summer 2023 (Alternatives B and C) or 2024 (Alternative D). Modules would be stored on the concrete footings installed during the previous summer construction season with self-propelled module transporters (SPMTs) stored under the modules and skirted to prevent snow and wildlife from moving underneath the staged modules. During the winter season of 2023–2024 (Alternatives B and C) or 2024–2025 (Alternative D), heavy-haul ice roads would be constructed onshore and offshore to support module transport (Figure D.4.4). All modules would be transported using SPMTs via ice road from the MTI to a staging area located on an onshore ice pad (location to be determined). From the staging area, all modules would be transported to the WPF for installation. Modules for drill sites BT4 and BT5 would be delivered via a second sealift in the summer of 2025 (Alternatives B and C) and 2026 (Alternative D) and moved to the Project area in the same manner as the modules for the WPF, BT1, BT2, and BT3 the following winter.

4.7.1.3 Module Transfer Island Maintenance and Decommissioning

The MTI would be inspected on an annual basis shortly after breakup to identify and repair any consequential damage for its service life (5 years). Following module mobilization from the MTI to the WPF, all work-surface facilities would be removed from the MTI.

At the end of the MTI service life, all gravel slope protection materials and other anthropogenic materials would be removed from the MTI, including the removal of all sheet and pipe piles.

Following the abandonment of the island, it is expected the island would be reshaped naturally by waves and ice. Based on observations from 2 exploratory islands (Resolution and Goose islands) at similar water depths in the Beaufort Sea that have been decommissioned using similar methods, the MTI would be expected to be reshaped to a crescent reminiscent of a natural barrier island within 10 to 20 years. (Resolution Island is located in the Sagavanirktok River Delta, and Goose Island is located in Foggy Island Bay.) The top of the MTI would likely drop to or below the water surface within the 10- to 20-year period following island abandonment. Based on previous North Slope experience, navigational aids would not be installed on the abandoned and decommissioned island due to the potential of the navigational aids being rendered inoperable due to damage (i.e., wave or ice impacts, erosion of the unarmored gravel material). In keeping with precedent for islands previously abandoned on the North Slope, the location, shape, and maximum island elevation would be documented by one or more post-abandonment surveys and reported to the U.S. Coast Guard (USCG) for publication in Notices to Mariners and inclusion in pertinent navigational charts. This practice would ensure mariners are made aware of the shoal and would minimize the possibility mariners would depend on a navigational aid that may be inoperable.

4.7.1.4 Ice Roads

Ice roads would be used for gravel-hauling operations required to construct the MTI and for sealift module delivery from the MTI to the Project area. Ice road widths would vary based on their intended use, with gravel-hauling ice roads being 70 feet wide and module hauling routes ranging from 105 to 120 feet wide; module hauling routes include ice roads for SPMT and support vehicle use. Ice road requirements for the Proponent's MTI are summarized in Table D.4.27.

Table D.4.27. Proponent's Module Transfer Island Ice Road Route Summary

Ice Road Type	Total Length (miles)	Width (feet)	Total Area (acres)[a]	Description
Tundra heavy haul and support	74.2	105	944.4	Onshore module delivery (SPMTs) and support vehicle traffic
Sea ice heavy haul	4.8	120	69.8	Offshore module delivery
Tundra gravel haul	35.7	70	302.9	Gravel haul route to construct MTI
Sea ice gravel haul	2.4	70	20.4	Gravel haul route to construct MTI

Note: MTI (module transfer island); SPMT (self-propelled module transporter)
[a] Total ice road area includes all years of ice road segment construction (i.e., some routes would be constructed more than once).

The Proponent's MTI would require a total of approximately 117.1 miles of ice roads (109.9 miles onshore, 7.2 miles offshore) resulting in a total ice road area of 1,337.5 acres (1,247.3 acres onshore, 90.2 acres offshore). No seawater would be used to construct onshore ice roads; a combination of seawater and freshwater would be used to construct offshore ice roads. Ice road mileage by year is summarized in Table D.4.28.

Table D.4.28. Proponent's Module Transfer Island Estimated Total Ice Road Mileage and Footprint by Year

Year	Ice Road Length (miles)	Ice Road Footprint (acres)
2022	0.0	0.0
2023	38.1	323.3
2024	0.0	0.0
2025	39.5	507.4
2026	0.0	0.0
2027	39.5	507.4
2028	0.0	0.0
Total[a]	117.1	1,338.1

Note: Ice roads include tundra and sea ice–based routes.

4.7.1.5 Ice Pads

Single-season and multi-season ice pads would be used to support the construction of the MTI and the delivery of the sealift modules to the Project area. Single-season and multi-season ice pads are described in Section 4.2.4.1, *Ice Pads*.

Option 1 would require 78.0 acres of single-season ice pads to support MTI construction and module delivery. Additionally, three 10.0-acre multi-season ice pads would be required to construct the gravel haul ice roads and module heavy-haul ice roads for both module delivery events. They would be located at BT1, near Atigaru Point, and midway between BT1 and Atigaru Point. The ice pads would be used to stage equipment at strategic locations along the ice road routes. The three multi-season ice pads would be constructed using Rolligons to deliver the equipment required to construct these pads. A total of 78.0 total acres of single-season ice pads would be used to support MTI construction and sealift module delivery.

4.7.1.6 Water Use

Freshwater requirements to support construction of the MTI, ice roads, and ice pads, and provide domestic water supply for camps, is provided by year and season in Table D.4.29. Total freshwater requirements for the Proponent's MTI would be 521.2 MG.

Table D.4.29. Proponent's Module Transfer Island Freshwater Use by Year (million gallons)

Year (season)	Ice Pads[a]	Ice Roads[b]	Camp Supply[c]	Total
2020–2021 (winter)	5.0	0.0	0.0	**5.0**
2021 (summer)	0.0	0.0	0.0	**0.0**
2021–2022 (winter)	11.4	109.4	2.3	**123.1**
2022 (summer)	0.0	0.0	1.4	**1.4**
2022–2023 (winter)	7.5	0.0	0.0	**7.5**
2023 (summer)	0.0	0.0	0.9	**0.9**
2023–2024 (winter)	14.1	170.6	3.2	**187.9**
2024 (summer)	0.0	0.0	0.0	**0.0**
2024–2025 (winter)	7.5	0.0	0.0	**7.5**
2025 (summer)	0.0	0.0	0.9	**0.9**
2025–2026 (winter)	14.1	170.6	2.3	**187.0**
2026 (summer)	0.0	0.0	0.0	**0.0**
Total	**59.6**	**450.6**	**11.0**	**521.2**

[a] Ice pad construction uses 0.25 million gallons of water per acre.
[b] Ice road construction uses 1.5 million gallons of water per mile for 35-foot-wide road and 3 million gallons of water per mile for 70-foot-wide road.
[c] Camp supply assumes 100 gallons of water per person per day.

4.7.1.7 Traffic

Construction of the MTI and delivery of the sealift modules to the Project area would require ground, air, and marine traffic. Ground traffic would include light-duty trucks, passenger trucks, gravel-hauling, and miscellaneous vehicles. Fixed-wing air traffic to Alpine and the Project airstrip would support personnel transport between the Project and other locations (e.g., Kuparuk, Deadhorse), though helicopters may be used to move personnel or equipment to Atigaru Point or the MTI. Sealift barges would bring the modules from points outside of Alaska and support vessel traffic would be between Atigaru Point and Oliktok Dock.

Traffic volumes to support construction of the Proponent's MTI and delivery of the sealift modules is summarized in Table D.4.30.

Table D.4.30. Proponent's Module Transfer Island Traffic Volumes (number of trips)

Year	Ground[a]	Fixed-Wing Trips Alpine[b]	Fixed-Wing Trips Willow[b]	Helicopter Alpine[c]	Helicopter Willow[c]	Sealift Barges	Support Vessels[d]
2021	43,680	25	0	15	0	0	0
2022	140,670	25	0	105	105	0	140
2023	43,783	0	80	0	65	5	60
2024	1,082,612	0	25	0	55	0	0
2025	43,770	0	30	0	60	1	24
2026	951,572	0	15	0	45	0	0
2027	0	0	0	0	0	0	0
Total	**2,306,087**	**50**	**150**	**120**	**330**	**6**	**224**

Note: Trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff; and a single vessel trip is defined as a docking and subsequent departure.
[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks) and module delivery (SPMTs).
[b] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.
[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection.
[d] Includes crew boats, tugs supporting sealift barges, and other support vessels.

4.7.1.8 Schedule

Figure D.4.14 provides a schedule for Option 1, Proponent's Module Transfer Island.

Figure D.4.14. Schedule of Activity for Option 1: Proponent's Module Transfer Island

Note: Ice Rd. (Ice Road); Mod. (Module); MS (multi-season); MTI (module transfer island). Sea Lift 1 includes WPF, BT1, BT2, BT3 facilities; Sea Lift 2 includes drill sites BT4 and BT5 facilities. Schedule is for Alternative B.

4.7.1.9 Proponent's Module Transfer Island Design Summary

Table D.4.31 summarizes the design characteristics of the Proponent's MTI.

Table D.4.31. Option 1: Proponent's Module Transfer Island Design Characteristics Summary

Element	Description
Location	Southwestern Harrison Bay, approximately 2.2 nautical miles north-northeast of the planned ice road shore crossing near Atigaru Point
Water depth	Approximately 8 feet, mean lower low water
Work surface	600 feet by 600 feet (8.3 acres) at +13 feet, mean lower low water
Design life	5 to 10 years
Dock	200-foot-long dock face at +16 feet, mean lower low water
Gravel fill volume	397,000 cubic yards
Seafloor footprint	12.8 acres
Screeding area	850 feet by 250 feet (4.9 acres)
Side slopes	3 horizontal to 1 vertical (3:1)
Side slope armor	6,000 total 4-cubic yard gravel filled bags
Ice ramp	7 horizontal to 1 vertical (7:1) slope; 120 feet wide
Onshore ice roads	109.9 miles (1,247.3 acres)
Offshore ice roads	7.2 miles (90.2 acres)
Single-season ice pads	78.0 acres
Multi-season ice pads	Three 10.0-acre multi-season ice pads
Freshwater use	521.2 million gallons

4.7.2 Option 2: Point Lonely Module Transfer Island

4.7.2.1 Module Transfer Island Construction

Point Lonely is a former U.S. Department of Defense site that is no longer in operation and has been decommissioned from its historical use. The site is located approximately 40 air miles northwest of the Proponent's MTI location, north of Teshekpuk Lake along the coast of the Beaufort Sea. The site still contains gravel infrastructure, including roads, pads, and an airstrip, though the majority of the structures have been removed or are otherwise abandoned. The site is now under the management of the BLM.

A new MTI, with a design life of 5 to 10 years, would be constructed at Point Lonely (approximately 0.6 miles offshore) to support sealift module delivery for the Project. Modules for the WPF, BT1, BT2, and BT3 would be delivered by sealift barges to the MTI during the summer of 2023 (Alternatives B and C) or 2024 (Alternative D). A second sealift would deliver modules for BT4 and BT5 in 2025 (Alternatives B and C) or 2026 (Alternative D). Modules would be stored on the MTI and mobilized from the MTI to the WPF via ice road the following year.

The MTI would be built through placement of gravel fill from the Tiŋmiaqsiuġvik area gravel mine in approximately 9.8 to 11.2 feet of water (an average of 10.5 feet) to a height of approximately 13 feet above MLLW. The MTI would consist of a 600-foot-square (8.3-acre) gravel work surface surrounded by 3:1 side slopes with gravel bags and a 200-foot-long sheet-pile dock with a top surface 16 feet above MLLW to facilitate barge offloading (Figure D.4.5). The resulting island footprint would be approximately 13.0 acres (based on the average 10.5-foot depth) on the seafloor.

Gravel haul and placement to construct the MTI would occur via ice road during the 2021–2022 winter construction season under Alternatives B and C and the 2023–2024 winter season under Alternative D, as soon as the ice roads have been constructed. Winter MTI construction would occur from a grounded sea ice pad surrounding the MTI. Sea ice within the MTI footprint, surrounding the MTI footprint, and the associated off-shore ice road would be bottom-fast (frozen to the seafloor) before construction of the MTI would begin. Sea ice within the MTI footprint would be cut and removed, and gravel would be placed into the opening until the design volume and approximate shape of the MTI have been attained. Installation of the sheet-pile offload dock would occur once the initial gravel placement is sufficient to support pile-driving activities and staging of materials and equipment. Sheet pile would be installed over a period of approximately 25 to 30 days, with approximately 3 to 6 hours of pile driving occurring per day, using vibratory driving equipment. After completion of the sheet-pile bulkhead, 24-inch diameter pipe pile would be installed to support the dock face and provide barge mooring, using both vibratory and impact pile-driving equipment. Installation of the pipe pile would take approximately 2 days with approximately 2 hours of pile driving per day (estimated at 1.5 hours of vibratory driving and 0.5 hour of impact driving per day). Winter pile driving for dock construction would cease prior to sea ice breakup. Because the MTI footprint and sea ice immediately surrounding the MTI would be bottom-fast, construction activities and materials would be unlikely to contact liquid seawater under the ice.

Onsite equipment and facilities to support winter construction would include an office, break room, envirovac, an emergency camp, mobile light plants, helipad, navigational aids, and a tripwire perimeter alarm and surveillance camera. An approximately 120-foot-tall communications tower would be erected at the start of MTI construction and would remain in place until after the first module delivery season is complete; the tower would be reinstalled for the second module delivery season and remain in place until MTI decommissioning. Two additional towers (i.e., repeaters) would be erected on a multi-season ice pads to relay communications signals to the Project area. Onsite facilities would also include a fuel storage area to hold multiple fuel tanks filled via ice road to support MTI construction. Workers to support winter construction would be housed at a 100-person construction camp located on the existing gravel pad at the Point Lonely site (Figure D.4.5). Except for equipment needed for summer construction activities, equipment would be removed from the MTI at the end of the winter construction season and transported via ice road to designated onshore staging areas.

During the following summer's open water season (2022 for Alternatives B and C and 2023 for Alternative D), construction equipment would be transported to the MTI by barge, likely from Oliktok Point. Workers to support summer construction would be housed at a 100-person camp located on a gravel pad at Point Lonely. Work on the MTI would recommence around early to mid-July once the risk of ice encroachment has passed. The gravel surface would be reworked and compacted to eliminate interstitial ice and then graded to the final design configuration. Large, pre-fabricated filter fabric panels would be installed on the side slopes by crane, and slope protection, in the form of 4-cubic-yard gravel-filled bags, would be installed on the fabric-covered side slopes from the seafloor to the work surface. All construction equipment not needed for subsequent activities on the MTI would be demobilized as soon as summer construction activities are completed.

4.7.2.2 Module Delivery

Prior to the sealift barge arrival, an 850- by 250-foot area (4.9 acres) in front of the dock face would be screeded to prepare for barge off-loading. Modules would be offloaded from 5 sealift barges onto the MTI in summer 2023 (Alternatives B and C) or 2024 (Alternative D). Modules would be stored on the concrete footings installed during the previous summer construction season with SPMTs stored under the modules and skirted to prevent snow and wildlife from moving underneath the staged modules. During the winter season of 2023–2024 (Alternatives B and C) or 2024–2025 (Alternative D), heavy-haul ice roads would be constructed onshore and offshore to support module delivery (Figure D.4.5). All modules would be transported using SPMTs via ice road from the MTI to a staging area located on the existing gravel Point Lonely East Pad. From this gravel staging pad, all modules would be transported to the WPF for installation. Modules for drill sites BT4 and BT5 would be delivered via a second sealift in the summer of 2025 (Alternatives B and C) and 2026 (Alternative D) and moved to the Project area in the same manner as the modules for the WPF, BT1, BT2, and BT3 the following winter.

4.7.2.3 Module Transfer Island Maintenance and Decommissioning

The MTI would be inspected on an annual basis shortly after breakup to identify and repair any observed damage for its service life (5 years). Following module mobilization from the MTI to the WPF, all on-pad facilities would be removed from the MTI.

At the end of the MTI service life, all gravel slope protection materials and other anthropogenic materials would be removed from the MTI, including the removal of all sheet and pipe piles.

Following abandonment of the island, it is expected that the island would be reshaped naturally by waves and ice. Based on observations from 2 exploratory islands (Resolution and Goose islands) at similar water depths in the Beaufort Sea that have been decommissioned using similar methods, the MTI would be expected to be reshaped to a crescent reminiscent of a natural barrier island within 10 to 20 years. (Resolution Island is located in the Sagavanirktok River Delta, and Goose Island is located in Foggy Island Bay.) The top of the MTI would likely drop to or below the water surface within the 10- to 20-year period following island abandonment. Based on previous North Slope experience, navigational aids would not be installed on the abandoned and decommissioned island due to the potential of the navigational aids being rendered inoperable due to damage (i.e., wave or ice impacts, erosion of the unarmored gravel material). In keeping with precedent for islands previously abandoned on the North Slope, the location, shape, and maximum island elevation would be documented by one or more post-abandonment surveys and reported to the USCG for publication in Notices to Mariners and inclusion in pertinent navigational charts. This practice would ensure mariners are made aware of the shoal and would minimize the possibility mariners would depend on a navigational aid that may be inoperable.

4.7.2.4 Ice Roads

Ice roads would be used for gravel hauling operations required to construct the MTI and for sealift module delivery from the MTI to the Project area. Ice road widths would vary based on their intended use, with gravel-hauling ice roads being 70 feet wide and module-hauling routes ranging from 105 to 120 feet wide; module-hauling routes include ice roads for SPMT and support vehicle use. Ice road requirements for the Point Lonely MTI are summarized in Table D.4.32.

Table D.4.32. Point Lonely Module Transfer Island Ice Road Route Summary

Ice Road Type	Total Length (miles)	Width (feet)	Total Area (acres)[a]	Description
Tundra heavy haul and support	150.0	105	1,909.1	Onshore module delivery (SPMTs) and support vehicle traffic
Sea ice heavy haul	1.2	120	17.5	Offshore module delivery
Tundra gravel haul	77.9	70	661.0	Gravel haul route to construct MTI
Sea ice gravel haul	0.6	70	5.1	Gravel haul route to construct MTI

Note: MTI (module transfer island); SPMT (self-propelled module transporter)
[a] Total ice road area includes all years of ice-road segment construction (i.e., some routes would be constructed more than once).

The Point Lonely MTI would require a total of approximately 229.7 miles of ice roads (227.9 miles onshore, 1.8 miles offshore) resulting in a total ice road area of 2,592.6 acres (2,570.1 acres onshore, 22.5 acres offshore). No seawater would be used to construct onshore ice roads; a combination of seawater and freshwater would be used to construct offshore ice roads. Ice road mileage by year is summarized in Table D.4.33.

Table D.4.33. Point Lonely Module Transfer Island Estimated Total Ice Road Mileage and Footprint by Year

Year	Ice Road Length (miles)	Ice Road Footprint (acres)
2022	0.0	0.0
2023	78.5	666.1
2024	0.0	0.0
2025	75.6	963.3
2026	0.0	0.0
2027	75.6	963.0
2028	0.0	0.0
Total[a]	229.7	2,592.7

Note: Ice roads include tundra and sea ice–based routes.

4.7.2.5 Ice Pads

Single-season and multi-season ice pads would be used to support the construction of the MTI and the delivery of the sealift modules to the Project area. Single-season and multi-season ice pads are described in Section 4.2.4.1, *Ice Pads*.

Option 2 would require 153.1 acres of single-season ice pads to support MTI construction and module delivery. Additionally, three 10.0-acre multi-season ice pads would be constructed to support the Point Lonely MTI and module moves. One would be located at BT2 and two would be located between BT2 and Point Lonely. These ice pads would be required to construct the gravel-haul and module heavy-haul ice roads. The ice pads would be used to stage equipment at strategic locations along the ice road routes. The three ice pads would be constructed using Rolligons to deliver the equipment required to construct these pads. A total of 153.1 total acres of single-season ice pads would be used to support MTI construction and sealift module delivery.

4.7.2.6 Water Use

Freshwater requirements to support construction of the MTI, ice roads, and ice pads, and provide domestic water supply for camps, is provided by year and season in Table D.4.34. Total freshwater requirements for the Point Lonely MTI would be 1,004.9 million gallons.

Table D.4.34. Point Lonely Module Transfer Island Freshwater Use by Year (million gallons)

Year (season)	Ice Pads[a]	Ice Roads[b]	Camp Supply[c]	Total
2020–2021 (winter)	7.5	0.0	0.0	**7.5**
2021 (summer)	0.0	0.0	0.0	**0.0**
2021–2022 (winter)	20.6	234.3	3.2	**258.1**
2022 (summer)	0.0	0.0	0.0	**0.0**
2022–2023 (winter)	7.5	0.0	0.0	**7.5**
2023 (summer)	0.0	0.0	0.0	**0.0**
2023–2024 (winter)	20.1	338.4	4.1	**362.6**
2024 (summer)	0.0	0.0	0.0	**0.0**
2024–2025 (winter)	7.5	0.0	0.0	**7.5**
2025 (summer)	0.0	0.0	0.0	**0.0**
2025–2026 (winter)	20.1	338.4	3.2	**361.7**
2026 (summer)	0.0	0.0	0.0	**0.0**
Total	**83.3**	**911.1**	**10.5**	**1,004.9**

[a] Ice pad construction uses 0.25 million gallons of water per acre.
[b] Ice road construction uses 1.5 million gallons of water per mile for 35-foot-wide road and 3 million gallons of water per mile for 70-foot-wide road.
[c] Camp supply assumes 100 gallons of water per person per day.

4.7.2.7 Traffic

Construction of the MTI and delivery of the sealift modules to the Project area would require ground, air, and marine traffic. Ground traffic would include light-duty trucks, passenger trucks, gravel hauling, and miscellaneous vehicles. Fixed-wing air traffic and helicopters between Point Lonely and the Alpine and Project airstrips would transport personnel to Point Lonely. Sealift barges would bring the modules from points outside of Alaska, and support vessel traffic would be between Atigaru Point and Oliktok Dock.

Traffic volumes to support construction of the Point Lonely MTI and delivery of the sealift modules is summarized in Table D.4.35.

Table D.4.35. Point Lonely Module Transfer Island Traffic Volumes

Year	Ground[a]	Fixed-Wing Trips Alpine[b]	Fixed-Wing Trips Willow[b]	Helicopter Trips Alpine[c]	Helicopter Trips Willow[c]	Sealift Barges	Support Vessels[d]
2021	43,680	25	0	15	0	0	0
2022	288,450	65	0	105	105	0	140
2023	43,783	0	100	0	65	5	60
2024	1,475,732	0	45	0	55	0	0
2025	43,770	0	50	0	60	1	24
2026	951,572	0	35	0	45	0	0
2027	0	0	0	0	0	0	0
Total	**2,846,987**	**90**	**230**	**120**	**330**	**6**	**224**

Note: Trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff; and a single vessel trip is defined as a docking and subsequent departure.
[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks) and module delivery (SPMTs).
[b] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.
[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection.
[d] Includes crew boats, tugs supporting sealift barges, and other support vessels.

4.7.2.8 Schedule

Figure D.4.15 provides a schedule for Option 2, Point Lonely Module Transfer Island.

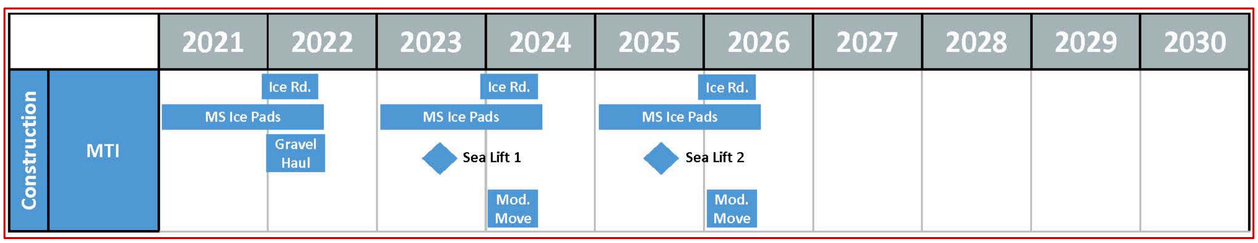


Figure D.4.15. Schedule of Activity for Option 2: Point Lonely Module Transfer Island

Note: Ice Rd. (Ice Road); Mod. (Module); MS (multi-season); MTI (module transfer island). Sea Lift 1 includes WPF, BT1, BT2, BT3 facilities; Sea Lift 2 includes drill sites BT4 and BT5 facilities. Schedule is for Alternative B.

4.7.2.9 Point Lonely Module Transfer Island Design Summary

Table D.4.36 summarizes the design characteristics of the Point Lonely MTI.

Table D.4.36. Option 2: Point Lonely Module Transfer Island Design Characteristics Summary

Element	Description
Location	Approximately 3,500 feet (0.6 miles) northwest of the Point Lonely Distant Early Warning site
Water depth	Approximately 10.5 feet, mean lower low water
Work surface	600 feet by 600 feet (8.3 acres) at +13 feet, mean lower low water
Design life	5 to 10 years
Dock	200-foot-long dock face at +16.0 feet, mean lower low water
Gravel fill volume	446,000 cubic yards
Seafloor footprint	13.0 acres
Screeding area	850 feet by 250 feet (4.9 acres)
Side slopes	3 horizontal to 1 vertical (3:1)
Side slope armor	6,900 total 4-cubic yard gravel filled bags
Ice ramp	7 horizontal to 1 vertical (7:1) slope; 120 feet wide
Onshore ice roads	227.9 miles (2,570.1 acres)
Offshore ice roads	1.8 miles (22.5 acres)
Single-season ice pads	153.1 acres
Multi-season ice pads	Three 10.0-acre multi-season ice pads
Freshwater use	1,004.9 million gallons

4.8 Comparison of Module Delivery Options

Table D.4.37 provides a summary comparison of the module delivery option components.

Table D.4.37. Summary Comparison of Impacts by Sealift Module Delivery Option

Component	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Gravel footprint (acres)	12.8	13.0
Gravel fill volume (million cubic yards)	397,000	446,000
Screeding footprint (acres)	4.9	4.9
Ice roads	117.1 total miles (1,337.5 acres) Gravel haul: 35.7 miles on tundra; 2.4 miles on sea ice Module delivery: 74.2 total miles on tundra; 4.8 miles on sea ice over two module delivery seasons	229.7 total miles (2,592.6 acres) Gravel haul: 77.9 miles on tundra; 0.6 miles on sea ice Module delivery: 150.0 total miles on tundra; 1.2 miles on sea ice over two module delivery seasons
Multi-season ice pads	Three 10.0-acre multi-season ice: One at BT1 One near Atigaru Point One midway between Atigaru Point and BT1	Three 10.0-acre multi-season ice pads: One at BT2 Two along ice road between BT2 and Point Lonely
Sealift delivery schedule (years)	Alternative B: 2023 and 2025 Alternative C: 2023 and 2025 Alternative D: 2024 and 2026	Alternative B: 2023 and 2025 Alternative C: 2023 and 2025 Alternative D: 2024 and 2026
Module mobilization (years)	Alternative B: 2024 and 2026 Alternative C: 2024 and 2026 Alternative D: 2025 and 2027	Alternative B: 2024 and 2026 Alternative C: 2024 and 2026 Alternative D: 2025 and 2027
Total freshwater usage (million gallons)	521.2	1,004.9
Total seawater usage (million gallons)	376.0	185.0
Ground traffic[a]	2,306,087 total trips	2,846,987 total trips

Component	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Fixed-wing traffic[b]	200 total flights Willow: 150 Alpine: 50	320 total flights Willow: 230 Alpine: 90
Helicopter traffic[c]	450 total flights Willow: 330 Alpine: 120	450 total flights Willow: 330 Alpine: 120
Sealift barge traffic	6 total trips	6 total trips
Support vessel traffic[d]	224 total trips	224 total trips
Construction camps and capacity (100-person capacity)	Camp for winter ice road construction (each season) on a multi-season ice pad Camp for module offload and transport on multi-season ice pad at Atigaru Point Camp for summer construction and module receipt would be located on a barge (i.e., Floatel) at module transfer island	Camp for winter ice road construction (each season) on existing gravel pad Camp for module offload and transport at Point Lonely on existing gravel pad Camp for summer construction and module receipt at Point Lonely on existing gravel pad

Note: BT1 (drill site BT1); BT2 (drill site BT2). Traffic trips are defined as one-way; a single flight is defined as a landing and subsequent takeoff; and a single vessel trip is defined as a docking and subsequent departure.

[a] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70/maxi dump trucks) and module delivery (SPMTs).

[b] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse) and include flights to the Alpine and Willow airstrips. Fixed-wing aircraft includes C-130, DC-6, Twin Otter/CASA, Cessna, or similar.

[c] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection.

[d] Includes crew boats, tugs supporting sealift barges, and other support vessels.

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Appendix E.1
Iñupiaq and Scientific Names

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List of Tables

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Some readers may better recognize locations, and common plant and animal names by their Iñupiaq or scientific names. The appendix provides Iñupiaq names for places (Table E.1.1), and Iñupiaq and scientific names for plants (Table E.1.2), mammals (Table E.1.3), fish (Table E.1.4), and birds (Table E.1.5). If an Iñupiaq name did not have a known scientific name, it was labeled as unknown (UNK), and vice versa.

Table E.1.1. Iñupiaq Place Names and Locations

Iñupiaq Name	Location
Anaqtuuvak	Anaktuvuk Pass
Bering Sea-mi Taġiuq	Bering Sea
Iiguaåruich	Arctic foothills
Kuukpik	Colville River
Kuukpaaårugmi niuqtuåviq	Kuparuk oil field
Niåliq Channel	Niġliq Channel - Westernmost channel of the Colville River Delta, where Nuiqsut is located
Uuliktuq nuvuġak	Oliktok Point
Taġium Siñaa Beaufort Sea-mi	Beaufort Sea coast
Tasiqpak Narvaq	Teshekpuk Lake

Source: (HDR 2015; NSB 2016, 2019; OHA 2018; SRB&A 2014, 2016; USACE 2012)

Table E.1.2. Iñupiaq, Scientific, and Common Names for Plants

Iñupiaq Name	Scientific Name	Common Name
Nunaŋiak, Nunaniat	*Alnus crispa*	Alder
Kavlaq, Kavlat, Kavluraq	*Arctostaphylos alpina*	Bearberry, black
Aŋurvak, Aŋutvak, Aŋurvat, Aŋurvait, Aŋurraich	*Arctostaphylos rubra*	Bearberry, red
Tinnik, Tinniik, Tiniich	*Arctostaphylos uva-ursi*	Bearberry, kinnickkinnick
Piḷġaurat, Piḷaurat, Piḷurat, Piḷaaqusaat, Piḷaġqusaaq, Piḷaġaqusaaq, Ikkuqutut*	*Cassiope tetragona*	Dwarf shrub
Niqaaq	*Cladonia rangiferina*	Lichen
Kivviġiruaq	*Dactylina spp.*	Lichen, finger
Paunġaq, Paunġak, Paunġat, Asiaq (Ti), Asiavik (Ti)	*Empetrum nigrum*	Crowberry
Paunġat	*Empetrum nigrum*	Crowberry leaves
Pikniq, Pikniik, Pitniq	*Eriophorum spp.*	Cottongrass
Qimmiurat	*Eriophorum spp.*	Cottongrass stems
Avvatchiqiq	*Ganoderma applanatum*	Fungus, bracket
Tilaaqiaq, Tilaaqiuq, Tilaaqqiq, Tilaaqqit, Tilaakiq, Papaksraq, Qayuksraq	*Ledum palustre*	Labrador tea
Masu, Aiġak, Piḷġa	UNK	Roots
Mumikataq	UNK	Lichen or brown moss
Mumiqattat, Kukuutit, Mumiqqat	UNK	Lichen, black
Palliksrat	UNK	Dried plants
Qaġliuraq	UNK	Moss, reindeer
Qimmiksit, Uġruq	UNK	Moss, sphagnum
Uġrunik	UNK	Moss, dried
Misuq, Ukpik	*Salix alaxensis*	Willow, felt-leaf
Qimmiuraq	*Salix spp.*	Willow, stems fuzzy ends
Uqpik, Ugpiik, Uqpiich, Uqpiit	*Salix spp.*	Willow
Asiaq (Nu), Asiraq, Asiat, Asiavik	*Vaccinium uliginosum*	Blueberry
Asiaviqutat, Asiaviqutaq (Nu)	*Vaccinium uliginosum*	Blueberry leaves, (Nu) Blueberry plant
Kimmigłaq, Kimmigñaq, Kimmiŋñat, Kimmigñauraq, Kikminnaq	*Vaccinium vitis-idaea*	Lowbush cranberry or lingonberry

Note: spp. (species); UNK (unknown)
Source: MacLean 2014

Table E.1.3. Iñupiaq, Scientific, and Common Names for Terrestrial and Marine Mammals

Iñupiaq Name	Scientific Name	Common Name
Aġviq	*Balaena mysticetus*	Bowhead whale
Qiḷalugaq, Sisuaq	*Delphinapterus leucas*	Beluga whale
Ugruk	*Erignathus barbatus*	Bearded seal
Natchiq, Qayaġulik	*Phoca hispida*	Ringed seal
Qasiġiaq	*Phoca largha*	Spotted seal
Nanuq	Ursus maritimus	Polar bear
Aġviġluaq	Eschrichtius robustus	Gray whale
Aiviq	Odobenus rosmarus divergens	Pacific walrus
Aġvisuaq	Phocoena phocoena	Harbor porpoise
UNK	Megaptera novaeangliae	Humpback whale
UNK	Balaenoptera acutorostrata	Minke whale
Aaġlu	Orcinus orca	Killer whale
Qaiġulik	Histriophoca fasciata	Ribbon seal
Qiḷalugaq tuugaalik	Monodon monoceros	Narwhal
UNK	Cystophora cristata	Hooded seal
Tuttuvak	*Alces americanus*	Moose
Tiġiganniaq	*Alopex lagopus*	Arctic fox (White)
Amaġuq	*Canis lupus*	Wolf
Qiḷaŋmiutaq	*Dicrostonyx groenlandicus*	Collared lemming
Qavvik	*Gulo gulo*	Wolverine
Aviŋŋapiaq	*Lemmus trimucronatus*	Brown lemming
Aviŋŋaq	*Microtus oeconomus*	Root/tundra vole
Itiġiaq	*Mustela erminea*	Ermine
Itiġiaq, Naulayuq	*Mustela nivalis*	Least weasel
Umiŋmak	*Ovibos moschatus*	Muskox
Tuttu	*Rangifer tarandus*	Caribou
Ugrugnaq	*Sorex tundrensis*	Tundra shrew
Siksrik, Sigrik	*Spermophilus parryii*	Arctic ground squirrel
Kayuqtuq, Qianġaq, Qiġñiqtaq	*Vulpes vulpes*	Red fox
Akłaq	*Ursus arctos*	Brown bear
Ukalliatchiaq	*Lepus americanus*	Snowshoe hare
Ugrugnaq	*Sorex ugyunak*	Barren ground shrew

Note: UNK (unknown)
Source: MacLean 2014

Table E.1.4. Iñupiaq, Scientific, and Common Names for Fish

Iñupiaq Name	Scientific Name	Common Name
Iqalugaq	*Boreogadus saida*	Arctic cod
Milugiaq	*Catostomus catostomus*	Longnose sucker
Qaaktaq	*Coregonus autumnalis*	Arctic cisco
Tiipuq	*Coregonus laurettae*	Bering cisco
Aanaakłiq	*Coregonus nasus*	Broad whitefish
Pikuktuuq	*Coregonus pidschian*	Humpback whitefish
Iqalusaaq	*Coregonus sardinella*	Least cisco
Kanayuq	*Cottus cognatus*	Slimy sculpin
Iłuuqiñiq	*Dallia pectoralis*	Alaska blackfish
Uugaq	*Eleginus gracilis*	Saffron cod
Siulik, Siułik	*Esox lucius*	Northern pike
Kakiḷaġnaq, Kakiḷasak, Kakalisauraq	*Gasterosteus aculeatus*	Threespine stickleback
Tittaaliq	*Lota lota*	Burbot
Nimibiaq	*Lethenteron camtschaticum*	Arctic lamprey
Paŋmaksraq, Paŋmagrak, Paŋmaġraq	*Mallotus villosus*	Capelin
Kanayuq	*Myoxocephalus quadricornis*	Fourhorn sculpin
Amaqtuuq	*Oncorhynchus gorbuscha*	Pink salmon (humpy)
Iqalugruaq, Qalugruaq	*Oncorhynchus keta*	Chum salmon (dog)
UNK	*Oncorhynchus nerka*	Red salmon (sockeye)
Iqalukpak, Taġyaqpak	*Oncorhynchus tshawytscha*	King salmon (chinook)
Aqalugruaq	UNK	Salmon
Iłhuaġniq	*Osmerus mordax*	Rainbow smelt
Saviġuunnaq	*Prosopium cylindraceum*	Round whitefish
Kakalisauraq	*Pungitius pungitius*	Ninespine stickleback
Iqalukpik, Paikḷuk, Aŋayuqaksraq, Qalukpik	*Salvelinus alpinus*	Arctic char
Qalukpik	*Salvelinus malma*	Dolly varden
Iqaluaqpak, Qaluaqpak	*Salvelinus namaycush*	Lake trout
Siiġruaq, Sii	*Stenodu leucichthys*	Sheefish or inconnu
Sulukpaugaq	*Thymallus arcticus*	Arctic grayling

Note: UNK (unknown)
Source: MacLean 2014

Table E.1.5. Iñupiaq, Scientific, and Common Names for Birds

Iñupiaq Name	Scientific Name	Common Name
Kurugaq	*Anas acuta*	Northern pintail
Niġlivik, Niġlivialuk	*Anser albifrons*	Greater white-fronted goose
Kurugaġnaq	*Anas americana*	American wigeon
Qaqlutuuq, Alluutaq	*Anas clypeata*	Northern shoveler
Qaiŋŋiq	*Anas crecca*	Green-winged teal
Kurugaqtaq	*Anas platyrhynchos*	Mallard
Qaqłukpalik	*Aythya marila*	Greater scaup
Qaqłutuuq	*Aythya affinis*	Lesser scaup
Niġlingaq	*Branta bernicla*	Brant goose
Iqsraġutilik	*Branta canadensis*	Canada goose
Kaŋuq	*Chen caerulescens*	Snow goose
Aaqhaaliq	*Clangula hyemalis*	Long-tailed duck
Qugruk	*Cygnus columbianus*	Tundra swan
Tuungaagrupiaq	*Melanitta americana*	Black scoter
Killalik	*Melanitta fusca*	White-winged scoter
Aviḷuqtuq	*Melanitta perspicillata*	Surf scoter
Paisugruk, Aqpaqsruayuuq	*Mergus serrator*	Red-breasted merganser
Igniqauqtuq	*Polysticta stelleri*	Steller's eider
Qavaasuk	*Somateria fischeri*	Spectacled eider
Amauligruaq	*Somateria mollissima*	Common eider
Qiŋalik	*Somateria spectabilis*	King eider
Aqargiq, Nasaullik	*Lagopus lagopus*	Willow ptarmigan
Niksaaktuŋiq	*Lagopus mutus*	Rock ptarmigan
Tuullik	*Gavia adamsii*	Yellow-billed loon
Taasiŋiq	*Gavia immer*	Common loon
Malġi	*Gavia pacifica*	Pacific loon
Qaqsrauq	*Gavia stellata*	Red-throated loon
Aqpaqsruayuuq	*Podiceps grisegena*	Red-necked grebe
Tiŋmiaqpak	*Aquila chrysaetos*	Golden eagle
Nipailuktaq	*Asio flammeus*	Short-eared owl
Ukpik	*Bubo scandiacus*	Snowy owl
Qilġiq	*Buteo lagopus*	Rough-legged hawk
Papiktuuq	*Circus cyaneus*	Northern harrier
Kirgaviatchauraq	*Falco columbarius*	Merlin
Kirgavik	*Falco peregrinus tundrius*	Arctic peregrine falcon
Aatqarruaq	*Falco rusticolus*	Gyrfalcon

Iñupiaq Name	Scientific Name	Common Name
Tiŋmiaqpak	*Haliaeetus leucocephalus*	Bald eagle
Tatirgaq	*Antigone candensis*	Sandhill crane
Tullignaq	*Arenaria interpres*	Ruddy turnstone
UNK	*Bartramia longicauda*	Upland sandpiper
Kimmitquilaq	*Calidris alba*	Sanderling
Siigukpaligauraq	*Calidris alpina*	Dunlin
Puviaqtuuyaaq	*Calidris bairdii*	Baird's sandpiper
Sigukpaligauraq	*Calidris canutus*	Red knot
Siiyukpaligauraq	*Calidris fuscicollis*	White-rumped sandpiper
Siigukpaligauraq	*Calidris himantopus*	Stilt sandpiper
Siigukpaligauraq	*Calidris mauri*	Western sandpiper
Puvviaqtuuq	*Calidris melanotos*	Pectoral sandpiper
Livilivillauraq	*Calidris minutilla*	Least sandpiper
Livilivillakpak	*Calidris pusilla*	Semipalmated sandpiper
Kurraquraq	*Charadrius semipalmatus*	Semipalmated plover
UNK	*Gallinago delicata*	Wilson's snipe
Sigukpalik	*Limnodromus scolopaceus*	Long-billed dowitcher
Turraaturaq	*Limosa lapponica*	Bar-tailed godwit
Sigguktuvak	*Numenius phaeopus*	Whimbrel
Auksruaq	*Phalaropus fulicarius*	Red phalarope
Auksruaq	*Phalaropus lobatus*	Red-necked phalarope
Tullik	*Pluvialis dominica*	American golden-plover
Tullivak	*Pluvialis squatarola*	Black-bellied plover
Uviññuayuuq	*Tringa flavipes*	Lesser yellowlegs
Satqagiiøaq	*Tryngites subruficollis*	Buff-breasted sandpiper
Iŋaġiq	*Cepphus grylle*	Black guillemot
Nauyavaaq	*Larus argentatus*	Herring gull
UNK	*Larus glaucescens*	Glaucous-winged gull
Nauyavasrugruk	*Larus hyperboreus*	Glaucous gull
UNK	*Larus thayeri*	Thayer's gull
UNK	*Rissa tridactyla*	Black-legged kittiwake
Isuŋŋaq	*Stercorarius longicaudus*	Long-tailed jaeger
Mitqutaiḷaq	*Sterna paradisaea*	Arctic tern
Migiaqsaayuk	*Stercorarius parasiticus*	Parasitic jaeger
Isuŋŋaġluk	*Stercorarius pomerinus*	Pomarine jaeger
Iqirgagiaq	*Xema sabina*	Sabine's gull
Saqsakiq	*Acanthis flammea* and *A. hornemanni*	Redpoll

Iñupiaq Name	Scientific Name	Common Name
Qupałuk, Putukiułuk	*Calcarius lapponicus*	Lapland longspur
UNK	*Catharus minimus*	Gray-cheeked thrush
Tulugaq	*Corvus corax*	Common raven
UNK	*Luscinia svecica*	Bluethroat
UNK	*Melospiza lincolnii*	Lincoln's sparrow
Misiqqaaqauraq, Piiġaq	*Motacilla tschutschensis*	Eastern yellow wagtail
Ikłiġvik	*Passerella iliaca*	Fox sparrow
Ukpisiuyuk	*Passerculus sandwichensis*	Savannah sparrow
Suŋaqpaluktuŋiq	*Phylloscopus borealis*	Arctic warbler
Amaułłigaaluq	*Plectrophenax nivalis*	Snow bunting
Misapsaq	*Spizella arborea*	American tree sparrow
Nuŋaktuaġruk	*Zonotrichia leucophrys*	White-crowned sparrow

Note: UNK (unknown)
Source: MacLean 2014

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Appendix E.2
Climate and Climate Change Technical Appendix

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Table of Contents

List of Tables

List of Acronyms

BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
°C	degrees Celsius
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CPAI	ConocoPhillips Alaska, Inc.
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
FHWA	Federal Highway Administration
IWG	Interagency Working Group on Social Cost of Carbon
GHG	greenhouse gas
GHG Model	Greenhouse Gas Lifecycle Model
GWP	global warming potential
Hw/D	headwater-diameter ratio
m	meter
MDP	Master Development Plan
MMT	million metric tons
NEPA	National Environmental Policy Act
N_2O	nitrous oxide
Project	Willow Master Development Plan Project
NEPA	National Environmental Policy Act
SCC	social cost of carbon
W/m^2	Watts per square meter

Glossary Terms

Active Layer – The top layer of ground subject to annual thawing and freezing in areas underlain by permafrost.
Anthropogenic – Resulting from the influence of human beings on nature.
Albedo – A measure of how a surface reflects incoming radiation; a surface with a higher albedo reflects more radiation than a surface with lower albedo.
Black Carbon – A component of fine particulate matter that is formed from incomplete combustion of fossil fuels and biomass.
Carbon Dioxide Equivalents (CO_2e) – The amount of greenhouse gases that would have an equivalent global warming potential as carbon dioxide when measured over a specific timescale.
Greenhouse Gases (GHG) – Gaseous compounds, including carbon dioxide, methane, and nitrous oxide, among others, that block heat from escaping to space and warm the Earth's atmosphere.
Lake-Tapping – Sudden drainage of lakes caused by ice melting or dislodging and opening up a drainage channel.
Particulate Matter 2.5 ($PM_{2.5}$) – Particulate matter less than 2.5 microns in aerodynamic diameter in ambient air; this fraction of particulate matter penetrates most deeply into the lungs.
Thermokarst – A land surface with karst-like features and hollows produced by melting ice-rich soil or permafrost.

1.0 AFFECTED ENVIRONMENT

Climate change is affecting natural systems across the globe with enhanced impacts in the Arctic. The atmosphere and oceans have warmed, ice cover is shrinking, and permafrost is melting in high-latitude and high-elevation regions. The dominant cause of the observed warming since the mid-twentieth century can be attributed to human influences (IPCC 2014).

1.1 Greenhouse Gases and Climate Change Overview

Major **greenhouse gases** (GHGs) include carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). GHGs are produced both naturally through volcanoes, forest fires, and biological processes, and through **anthropogenic** activities such as the burning of fossil fuels, land use and water management changes, and agricultural processes. Since GHGs absorb infrared radiation emitted from the Earth's surface, they block heat from escaping to space and warm the Earth's atmosphere. GHGs are necessary for keeping the planet at a habitable temperature and without GHGs, Earth's surface temperature would be around 60 degrees Fahrenheit (°F) cooler than it is now. Natural biological and geological processes regulate levels of naturally occurring GHGs in the atmosphere; however, anthropogenic emissions haven driven atmospheric concentrations of GHGs to levels unprecedented in the last 800,000 years. Concentrations of CO_2, CH_4, and N_2O have increased by 40%, 150%, and 20% respectively since 1750, largely due to economic and population growth (IPCC 2014). Continued emissions of GHGs are expected to continue to warm the planet in the future.

Although **black carbon** is not a GHG, it affects climate in a variety of ways. Black carbon is emitted as a combustion byproduct and the concentration of black carbon can vary spatially, seasonally, and vertically in the atmosphere (AMAP 2015; Creamean, Maahn et al. 2018; Stohl, Klimont et al. 2013; Xu, Martin et al. 2017). Black carbon affects the climate by absorbing and scattering solar radiation (i.e., sunlight). It can also influence clouds by altering the size and number of water droplets and ice crystals in water and ice clouds. Black carbon in cloud droplets decreases the cloud **albedo**, which heats and dissipates the clouds. This also changes the temperature structure within and around the cloud, changing cloud distribution.

1.2 Regulatory Framework

On March 28, 2017, Executive Order (EO) 13783 "Promoting Energy Independence and Economic Growth" was issued. EO 13783 required agencies to immediately review existing regulations and suspend, revise, or rescind those that burden the development of domestic energy resources beyond the degree necessary to protect the public interest or otherwise comply with the law. As a result, many of the previous existing EOs and federal guidance related to climate change have been revoked or rescinded.

On October 30, 2009, the U.S. Environmental Protection Agency (EPA) issued the reporting rule for major sources of GHG emissions (40 CFR 98). The rule required a wide range of sources and source groups to record and report selected GHG emissions. Various oil and gas operations are required to monitor and report GHG emissions under this regulation. The State of Alaska does not have any GHG regulations beyond federal regulations.

1.3 Observed Climate Trends

1.3.1 Arctic

Global warming impacts observed globally and nationally are amplified in the Arctic. Mean air temperature increases in the Arctic are double the global rate of increase. Average air temperatures in the region have increased by 3°F annually and 6°F in the winter over the past 60 years (Melillo, Richmond et al. 2014). The annual average air temperature anomaly (meaning the departure from average conditions) for land north of 60°N latitude was the second largest from October 2016 to September 2017 since 1900, after 2015 to 2016 (Richter-Menge, Overland et al. 2017).

Spring snow cover extent, observed by satellites, has been decreasing over arctic land since 2005, especially in May and June (Derksen, Brown et al. 2017). In 2017, snow cover extent was the lowest on record for April and May in the North American Arctic, and in 2016, snow cover extent was the lowest on record for June. Decreased snow cover extent and shorter snow cover duration in the Arctic is a reinforcing feedback effect. As more of the sun's energy is absorbed by the dark land surface, warmer surfaces further reduce snow cover (Melillo, Richmond et al. 2014).

The 2017 winter maximum ice extent was the lowest on record, and the third consecutive year of record low sea ice extent (Richter-Menge, Overland et al. 2017). Recent measurements of sea ice extent show it is approximately half of the size of sea ice extent when measurements began in September 1979 (Melillo, Richmond et al. 2014). The extent of multiyear sea ice (ice that doesn't melt in summer) has also decreased, now only comprising 21% of ice cover in 2017, compared to 45% in 1985 (Richter-Menge, Overland et al. 2017). Generally, Arctic sea ice extent is two to three times larger at the end of winter (March) than the end of summer (September) (Perovich, Meier et al. 2017). But from1981 to 2010, anomalies in the ice extent show ice losses of 2.7% per decade in March and 13.2% per decade in September (Perovich, Meier et al. 2017). Similar to decreases in snow cover extent, decreased sea ice extent also has a feedback effect on climate. An increased amount of the sun's energy is absorbed by the open ocean relative to oceans covered by ice, leading to increased rate of sea ice melting. Reductions in sea ice also make the Arctic more accessible by ships for transportation, oil and gas exploration, and tourism. This can lead to increased GHG emissions as well as other risks such as oil spills and drilling or maritime-related accidents (Melillo, Richmond et al. 2014).

Rising air temperatures over land affect the Arctic permafrost layer. Permafrost is material that exists at or below 32°F (0 degrees Celsius [°C]) for at least 2 years, and the **active layer** is the layer above the permafrost that thaws seasonally. The northern circumpolar permafrost zone stores 1,700 petagrams (gigatons) of organic carbon, locked in place due to the slow rate of plant material decomposition in the frozen ground (Schuur, Abbott et al. 2013). With rising temperatures and decreasing snow cover, permafrost extent is predicted to decrease significantly by the year 2100 (Slater and Lawrence 2013). Thawing permafrost releases CO_2 and CH_4 to the atmosphere, as well as delivering organic-rich soils to the bottoms of lakes, resulting in decomposition that releases further CH_4. These emissions can accelerate climate feedback effects (Markon, Trainor et al. 2012).

Reduction in sea ice has led to increased primary productivity in the Arctic Ocean (Richter-Menge, Overland et al. 2017). Warmer temperatures combined with reduced ice cover have led to greening of the tundra and increases in soil moisture and the amount of snow meltwater available. These changes have led to increased active layer depth, changes in herbivore activity patterns, and reductions in human usage of the land due to a shorter period of time when the ground is frozen (Clement, Bengtson et al. 2013; Epstein, Bhatt et al. 2017). Though the greening of the tundra can store carbon as biomass, the effect of these changes in the Arctic has been a net release of carbon into the atmosphere (Epstein, Bhatt et al. 2017; Richter-Menge, Overland et al. 2017).

Black carbon has a magnified impact on climate in the Arctic due to the snow and ice albedo feedback. This feedback occurs when black carbon settles on top of snow or ice and decreases the reflectivity (albedo) of the surface. This allows more heat to be absorbed by the surface, leading to increased melting, which further decreases the albedo. This feedback is prominent in the Arctic because so much of the surface is snow and ice, which have high albedo.

1.3.2 North Slope

Similar to the Arctic as a whole, the North Slope has experienced increased average temperatures, decreased sea ice and snow cover extent, an expanded growing season, and thawing permafrost. Annual average temperatures in North Slope are expected to be -11.2°F to -9.0°F by the end of this decade (i.e., 2019). This is 2.3°F higher than the annual average from 1961 to 1990, which ranges from -13.5°F to 11.3°F. By 2050, the annual average temperature is expected to be -8.9°F to -6.8°F (SNAP 2018).

Over the 35-year record (1982 to 2016), the North Slope has shown substantial increases in tundra greenness (Richter-Menge, Overland et al. 2017). A warming climate, in addition to regulatory changes and methods for measuring frost depth, has contributed to a reduction in the tundra-travel season from 200 days in the 1970s to less than 120 days in 2003 (NSB 2014). With continued climate warming and precipitation changes, the tundra travel season is expected to shorten further. Since the mid-1980s, Alaskan permafrost on the Arctic coast has warmed between 6°F to 8°F at a depth of 3.3 feet (1 meter [m]). In 2016, all but one permafrost observational site documented record high temperatures at 65.6 feet (20 m) in depth on the North Slope. Depth temperatures at 65.6 feet (20 m) in this region have been increasing at rates between 0.38°F and 1.19°F per decade since 2000. Active layer depth was at a 210-year maximum on the North Slope in 2016 (Richter-Menge, Overland et al. 2017).

1.4 Observed Greenhouse Gas Trends

1.4.1 National

GHG emissions in the U.S. are tracked by the EPA and documented in the Inventory of U.S. Greenhouse Gases and Sinks. In 2017, 6,457 million metric tons (MMT) of **carbon dioxide equivalents** (CO_2e) were emitted in the U.S. The major economic sectors contributing to GHG emissions in the U.S. in 2017 were transportation (29%), electricity generation (28%), industry (22%), and agriculture (9%) (EPA 2019). CO_2 from fossil fuel combustion has accounted for approximately 77% of U.S. GHG emissions since 1990. From 1990 to 2017, CO_2 emissions from fossil fuel combustion increased by 3.7%, and in 2016, the U.S. accounted for 15% of global fossil fuel emissions (EPA 2019).

1.4.2 Alaska

The EPA documents GHG emissions from Alaska in the Alaska Greenhouse Gas Emissions Inventory. Emissions are calculated using a top-down approach where emissions factors are applied to statewide activity data from 1990 to 2015. In 2015, approximately 40 MMT CO_2e were emitted in Alaska. This is a decrease of approximately 8% from 1990 levels, and a decrease of approximately 23% from the peak emissions observed in 2005 (ADEC 2018).

The industrial sector, including the oil and gas industry, is the major contributor to GHG emissions in Alaska, followed by the transportation, residential and commercial, and electrical generation sectors. The waste, agricultural, and industrial process sectors each contribute less than 1% of GHG emissions in Alaska (ADEC 2018). In 2015, Alaska was the 40th highest state in the U.S. in terms of total energy-related CO_2 emissions and the 4th highest in terms of per capita emissions (USEIA 2018). Alaska represents about 0.61% of total U.S. GHG emissions (EPA 2017) and 0.09% of global GHG emissions (IPCC 2014).

1.5 Projected Climate Trends and Impacts in the Project Area

Snow cover duration in Alaska is expected to drop with a later date of first snowfall and earlier snowmelt (Markon, Trainor et al. 2012). Models predict permafrost thawing will continue, with some models predicting that large parts of Alaska will lose all near-surface permafrost by the end of the century. This will impact rural Alaskan communities by likely disrupting sewage systems and community water supplies. The increasing trend in Alaskan growing season length is also projected to continue. This change will reduce water storage as well as increase the risk and extent of wildfires and insect outbreaks in the region. Warmer temperatures, wetland drying, and increased summer thunderstorms have increased the number of wildfires in Alaska. The annual area burned is projected to double by midcentury and triple by the end of the century, releasing more carbon to the atmosphere (Melillo, Richmond et al. 2014).

Warmer temperatures in the Willow Master Development Plan Project (Project) area will lead to a deeper active layer, which would affect the surrounding ecosystem. A deeper active layer would allow improved water drainage and the migration of deeper-rooted plant communities further north. Changes in plant communities would also be driven by the expanded growing season and warmer, drier soils. These vegetation changes would promote soil formation as root development and organic matter in the soil profile increase.

As the active layer deepens, damage from traffic over the surface during non-frozen periods would likely increase, due to accelerated erosion and subsidence of permafrost. Permafrost thawing could also lead to **thermokarst** or slumping, resulting in increased nutrient loading and suspended sediment in lakes and rivers. Warmer temperatures may lead to an increase in the frequency of **lake-tapping** (sudden drainage) events as degrading ice wedges integrate into drainage channels at lower elevations.

Arctic fish species will be affected by increased water temperatures as air temperatures increase, but this impact is difficult to predict. Arctic bird species will be affected by habitat loss as aquatic and semiaquatic habitats are converted into drier habitats. A reduction in available habitat would likely cause changes in bird distributions, increased competition for resources, and declines in productivity.

Paleontological resources could be adversely affected by climate change, but the impact is difficult to determine. Paleontological sites may more rapidly decompose in a warmer climate, and sites on hillsides, bluff faces, river banks, and terraces may be destroyed by mass wasting. Erosion may lead to increased exposure of known paleontological sites. Many known paleontological sites in the Project area have been exposed due to erosion with few negative impacts.

As with paleontological resources, cultural resources on the North Slope could also be impacted by mass wasting, warmer temperatures, and erosion. In addition, as the permafrost thaws and the active layer deepens, cultural resources may be incorporated into the active layer. These sites would then be exposed to cryoturbation (frost mixing) and vertical disturbances that may cause sites at different vertical layers to become mixed. These disturbances can occur in both vertical directions as seasonal frost cracking can cause downward movement, and frost heaving and sorting, ice wedging, and involutions can push artifacts upwards.

Climate change may impact the accessibility of mineral material deposits on the North Slope. While the existence and location of these deposits will not be affected, the excavation process may be made easier, due to the thawing permafrost, or more difficult, as developing deposits in areas with thawed permafrost may require water removal or excavation in swampy conditions.

2.0 ANALYSIS METHODS

2.1 Overview

To evaluate the potential contribution of the Project to global climate change, emissions were used as a proxy for climate change impacts. The amount of GHG emissions emitted by the Project under various alternatives was calculated. Emission metrics facilitate multi-component climate policies by allowing emissions of different GHGs and other climate forcing agents to be expressed in a common unit (so-called 'CO_2-equivalent or CO_2e emissions') (IPCC 2014). The Global Warming Potential (GWP) was introduced in the Intergovernmental Panel on Climate Change's First Assessment Report, where it was also used to illustrate the difficulties in comparing components with differing physical properties using a single metric. Each GHG has a GWP that accounts for the intensity of the GHG's heat trapping effect and its longevity in the atmosphere.

The 100-year GWP was adopted by the United Nations Framework Convention on Climate Change (IPCC 2014) and its Kyoto Protocol. In addition, the EPA uses the 100-year time horizon in its Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017 (EPA 2019). The 100-year GWP is only one of several possible emission metrics and time horizons. The Intergovernmental Panel on Climate Change (IPCC) also presented updated 100-year and 20-year GWPs in the Fifth Assessment Report (AR5) (IPCC 2014).

As noted by the IPCC (2014) the choice of emission metric and time horizon depends on type of application and policy context; hence, no single metric is optimal for all policy goals. All metrics have shortcomings and choices contain value judgments, such as the climate effect considered and the weighting of effects over time (which explicitly or implicitly discounts impacts over time), and the climate policy goal and the degree to which metrics incorporate economic or only physical considerations. There are significant uncertainties related to metrics, and the magnitudes of the uncertainties differ across metric type and time horizon. In general, the uncertainty increases for metrics along the cause–effect chain from emission to effects. The weight assigned to non-CO_2 climate forcing agents relative to CO_2 strongly depends on the choice of metric and time horizon (IPCC 2014). The GWP metric compares components based on radiative forcing, integrated up to a chosen time horizon.

In this Environmental Impact Statement (EIS), all Project GHG emissions were converted to units of CO_2e for ease of comparison using the three sets of GWP values shown in Table E.2.1. The choice of time horizon considerably affects the weighting of short-lived climate forcing agents, such as methane.

Table E.2.1. Global Warming Potential Factors

Time Horizon	CO_2	CH_4	N_2O	Rationale for Time Horizon
100 years	1	25	298	Used by IPCC in its Fourth Assessment Report (IPC 2007). Used by the Environmental Protection Agency in its GHG inventories and GHG reporting rule requirements under 40 CFR 98(a) (EPA 2019).
20 years	1	84	264	Used by IPCC in its Fifth Assessment Report (IPCC 2014)
100 years	1	28	265	Used by IPCC in its Fifth Assessment Report (IPCC 2014)

Note: CFR (Code of Federal Regulations); CH_4 (methane); CO_2 (carbon dioxide); GHG (greenhouse gas); IPCC (Intergovernmental Panel on Climate Change); N_2O (nitrous oxide)

2.2 Direct Greenhouse Gas Emissions Calculation Methods

ConocoPhillips Alaska, Inc. (CPAI) developed a Project emissions inventory (CPAI 2019) of all known emissions sources (e.g., vehicles, aircraft, drill rigs, generators) that would be present during the construction and life of the Project for Alternative B (Proponent's Project). The Bureau of Land Management (BLM) reviewed the emissions inventory and used it as the basis to estimate emissions from Alternatives C (Disconnected Infield Roads) and D (Disconnected Access). GHG emissions were calculated for each alternative as part of this inventory to estimate the Project's direct GHG emissions.

All action alternatives would include construction, drilling, routine operations, well workovers and interventions, and module transport. Emissions from these activities would come from stationary combustion sources, mobile on-road and nonroad tailpipe combustion sources, fugitive sources, aircraft sources, and marine vessel sources. GHG emissions quantified from these activities include CO_2, CH_4, and N_2O. The GWPs shown in Table E.2.1 were used to calculate total CO_2e. For additional information regarding the methods used to estimate emissions for each alternative, see Chapter 2 of the Willow Master Development Plan (MDP) Air Quality Technical Support Document provided in Appendix E.3, *Air Quality Technical Appendix*.

For Alternatives B and C, the Project would begin construction in the year 2020 and end production in 2050 for a 30-year Project lifetime. For Alternative D, the Project would begin construction in 2020 and end production in 2052 for a 32-year Project lifetime.

2.3 Indirect Greenhouse Gas Emissions Calculation Methods

The Bureau of Ocean Energy Management's (BOEM's) Greenhouse Gas Lifecycle Model (Wolvovsky and Anderson 2016) is used to estimate indirect GHG emissions from transportation, refinement, and oil usage. This model was developed to support the Outer Continental Shelf Oil and Gas Leasing Program: 2017–2022 Preliminary EIS and it represents the best available resource for estimating indirect GHG emissions from petroleum products refined and consumed domestically. A description of the model's capabilities and methodology can be found in Wolvovsky and Anderson (2016).

For the EIS, BOEM estimated the downstream GHG emissions associated with the consumption of the oil and gas produced from the Project as well as the energy substitutes (ranging from other oil sources to renewable sources). BOEM's Market Simulation Model estimates these energy substitutes that could replace production from the Project, or equivalently be displaced due to the Project. BOEM's Office of Environmental Programs developed the GHG Lifecycle Model to estimate the full lifecycle emissions from both production and consumption of Outer Continental Shelf resources. For this Project, only the downstream portion of the model was used as the upstream component is derived in combination with an offshore-specific separate model. BOEM's GHG analysis for the Project is limited to the emissions associated with the processing and consumption of oil and gas resources and not the actual production of the resources which were calculated as discussed in Section 2.2, *Direct Greenhouse Gas Emissions Calculation Methods*. For Alternatives B and C, oil production would begin in 2024 and end in 2050. For Alternative D, oil production would begin in 2026 and end in 2052.

2.4 Social Cost of Carbon

A protocol to estimate what is referenced as the "social cost of carbon" (SCC) associated with GHG emissions was developed by a federal Interagency Working Group on Social Cost of Carbon (IWG), to assist agencies in addressing EO 12866, which requires federal agencies to assess the cost and the benefits of proposed regulations as part of their regulatory impact analyses. The SCC is an estimate of the economic damages associated with an increase in carbon dioxide emissions and is intended to be used as part of an economic cost-benefit analysis for proposed rules. As explained in the Executive Summary of the 2010 SCC Technical Support Document "[t]he purpose of the [SCC] estimates…is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or 'marginal,' impacts on cumulative global emissions" (IWG 2010). While the SCC protocol was created to meet the requirements for regulatory impact analyses during rulemakings, BLM has received requests to expand the use of SCC estimates to program and project-level National Environmental Policy Act (NEPA) analyses.

The decision was made not to expand the use of the SCC protocol for the oil and gas leasing actions discussed in this EIS for several reasons. Most notably, this Project-level action is not rulemaking for which the SCC protocol was originally developed. Second, on March 28, 2017, the President issued EO 13783 which, among other actions, directed that the IWG be disbanded and that the technical support documents upon which the protocol was based be withdrawn as no longer representative of governmental policy. The EO further directed agencies to ensure that estimates of the social cost of carbon and GHGs used in regulatory analyses "are based on the best available science and economics" and are consistent with the guidance contained in Office of Management and Budget Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (EO 13783, Section 5(c)). In compliance with Circular A-4 guidance, interim protocols have been developed for use in the rulemaking context. However, the Circular A-4 does not apply to non-rulemaking program or project decisions, so there is no EO requirement to apply the SCC protocol to Project decisions like this EIS.

Further, NEPA does not require a cost-benefit analysis (40 CFR 1502.23), although NEPA does require consideration of "effects" that include "economic" and "social" effects (40 CFR 1508.8(b)). Without a complete monetary cost-benefit analysis, which would include the social benefits of the proposed action to society as a whole and other potential positive benefits, including only an SCC cost analysis would be unbalanced, potentially inaccurate, and not useful to the decisionmaker. The economic analysis in this EIS is discussed in Section 3.15, *Economics*. Any increased economic activity that is expected to occur with the proposed action is simply an economic impact, rather than an economic benefit. Some people may perceive increased economic activity as a 'positive' impact that they desire to have occur whereas another person may view increased economic activity as negative or undesirable due to potential increase in local population, competition for jobs, and concerns that changes in population will change the quality of the local community. Economic impacts are distinct from "economic benefits" as defined in economic theory and methodology (Kotchen 2011; Watson, Wilson et al. 2007), and the socioeconomic impact analysis required under NEPA is distinct from an economic cost-benefit analysis, which is not required and was not performed in this EIS.

The fact that climate impacts associated with GHG emissions were not quantified in terms of monetary costs does not mean that climate impacts were ignored in this EIS. Readers are referred to Sections 3.2.1.1, *Observed Climate Trends and Impacts in the Arctic and on the North Slope*, and 3.2.1.2, *Projected Climate Trends and Impacts in the Arctic and on the North Slope*, of the Willow MDP EIS and Sections 1.2, 1.3 and 1.5 of this Appendix for descriptions of climate change trends in the Arctic and on the North Slope and for discussion of the potential effects of climate change on the region. In addition to the qualitative climate change discussions discussed above, BLM quantified the direct and indirect GHG emissions associated with the Action Alternatives in this EIS (see Table 3.2.2 in Section 3.2, *Climate and Climate Change*, of the Willow MDP EIS; and Tables E.2.2, E.2.3, and E.2.4 in this appendix). Furthermore, Section 3.2.1.3, *Trends in U.S. and Alaska Greenhouse Gas Emissions*, in the Willow MDP EIS provides an inventory of recent GHG emissions at various geographic scales, in units of million metric tons per year, against which Project-related direct and indirect emissions are compared for each action alternative (Willow MDP EIS Sections 3.2.2.2, 3.2.2.3, and 3.2.2.4) to provide an estimate of the relative contribution of such emissions at various geographic scales.

BLM took the approach of referencing climate change trends and potential climate impacts at different scales and calculating direct and indirect GHG emissions because climate change and potential climate impacts, in and of themselves, are often not well understood by the public (Etkin and Ho 2007; NRC 2009). Therefore, BLM has provided data and information in a manner that follows many of the guidelines for effective climate change communication developed by the National Academy of Sciences (NRC 2010) by making the information more readily understood and relatable to the decision-maker and the public. This approach recognizes that there are adverse environmental impacts associated with the development and use of fossil fuels and discusses potential impacts qualitatively and effectively informs the decision-maker and the public of the potential for GHG emissions and the potential implications of climate change.

Finally, the SCC protocol does not measure the actual incremental impacts of a project on the environment and does not include all damages or benefits from carbon emissions. The SCC protocol estimates economic damages associated with an increase in carbon dioxide emissions—typically expressed as a one metric ton increase in a single year—and includes, but is not limited to, potential changes in net agricultural productivity, human health, and property damages from increased flood risk over hundreds of years. The estimate is developed by aggregating results “across models, over time, across regions and impact categories, and across 150,000 scenarios” (Rose, Turner et al. 2014). The dollar cost figure arrived at based on the SCC calculation represents the value of damages avoided if, ultimately, there is no increase in carbon emissions. However, the dollar cost figure is generated in a range and provides little benefit in assisting the BLM Authorized Officer’s decision for program or project-level analyses, especially given that there are no current criteria or thresholds that determine a level of significance for SCC monetary values.

3.0 ENVIRONMENTAL CONSEQUENCES

3.1 Effects of the Project on Climate Change

3.1.1 Alternative A: No Action

Under Alternative A, the Project would not occur. Direct and indirect GHG emissions from the Project would not occur and contribute to climate change. Current trends in global, U.S., and Alaska GHG emissions would continue, unaffected by the Project. For ease of comparison to the action alternatives, GHG emissions in the No Action Alternative are assigned a baseline value of zero in this EIS, reflecting the status quo and current GHG emissions trends in the absence of the Project.

3.1.2 Alternative B: Proponent’s Project

Alternative B direct and indirect CO_2e emissions are quantified and described in the following sections. Black carbon effects on climate is also discussed.

3.1.2.1 Direct Greenhouse Gas Emissions

Direct and indirect emissions of the GHGs CO_2, CH_4, and N_2O will impact the climate. The Project is also expected to produce a small amount of sulfur dioxide, a GHG that has an overall cooling effect; however, the effect of sulfur dioxide emissions would be negligible. Direct emissions for the Project include, but are not limited to, emissions from vehicle traffic, air traffic, power generation, and drill rigs.

GHGs have long lifetimes of 10 to 100 years before they are chemically broken down or otherwise removed from the atmosphere through absorption or deposition. Since GHGs are relatively stable, changes in GHG emissions have long-lasting effects on the climate. Alternative B direct GHG emissions estimated over the 30-year Project lifetime are provided in EIS Section 3.2.2.3, *Alternative B: Proponent's Project*). Emissions are given in CO_2e units to account for the GWP of pollutants and were calculated using GWP values for both 100-year and 20-year time horizon (Table E.2.1). Note that the Project activities vary considerably over the life of the Project and GHG emissions in any given year may be higher or lower than annual average GHG emissions (Table E.2.2).

Table E.2.2. Annual Average Gross Greenhouse Gas Emissions for Alternative B (thousand metric tons per year)

GHG Emissions	CO_2	CH_4	N_2O	CO_2e (IPCC AR4 100-year GWP)	CO_2e (IPCC AR5 100-year GWP)	CO_2e (IPCC AR 5 20-year GWP)
Direct	784	0.318	0.0018	793	794	812
Indirect	7,890	0.433	0.0667	7,921	7,920	7,944
Total[a]	**8,675**	**0.751**	**0.0685**	**8,714**	**8,714**	**8,756**

Note: AR4 (Fourth Assessment Report); AR5 (Fifth Assessment Report); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); CH_4 (methane); GHG (greenhouse gas); GWP (global warming potential); IPCC (Intergovernmental Panel on Climate Change); N_2O (nitrous oxide)
[a] Total values may have small differences due to rounding. Likewise, CO_2e values may be subject to rounding.

3.1.2.2 Indirect and Total Greenhouse Gas Emissions

Indirect emissions are expected to come from transportation, refinement, and downstream consumption of the oil extracted by the Project. Natural gas extracted from the Project would be reinjected into the well and would not be transported for consumption. The indirect GHG emissions shown in Table E.2.2 were calculated using BOEM's Greenhouse Gas Lifecycle Model (GHG Model) (BOEM 2019; *Appendix E.2B, Market Substitutions and Greenhouse Gas Downstream Emissions Estimates*) and are the gross emissions that would result from the processing and consumption of Project oil if there were not market effects considered.

Indirect gross GHG emissions estimated over the 30-year Project lifetime are shown in Willow MDP EIS Section 3.2.2.3, *Alternative B: Proponent's Project*. The Alternative B annual average gross indirect and total GHG emissions (Table E.2.2) are calculated by dividing the gross indirect and total GHG emissions by the 30-year Project lifetime. As in the case of direct emissions, GHG emissions in any given year may be higher or lower than annual average GHG emissions because Project activities vary considerably over the life of the Project. Note: BOEM (2019) also estimated the emissions that the Project would displace considering market effects; the substituted emissions over the Project life are reported in Willow MDP EIS Section 3.2.2, *Environmental Consequences: Effects of the Project on Climate Change*.

3.1.2.3 Black Carbon Effects on Climate

Black carbon is a short-lived pollutant with a lifetime of several days to weeks (AMAP 2011, 2015; Paris, Stohl et al. 2009). Estimates of black carbon's effect on climate is highly uncertain, but according to the 2015 Arctic Monitoring and Assessment Programme Assessment, there is a "very high probability that black carbon emissions … have a positive forcing and warm the climate." In addition, the Intergovernmental Panel on Climate Change has stated that black carbon emissions must fall by at least 35% across all sectors from 2010 levels by 2050 to limit global warming to 1.5°C (2.7°F) (IPCC 2018).

Black carbon is a by-product of incomplete combustion. It is removed from the atmosphere through wet and dry deposition. Concentrations of black carbon vary depending on the season (AMAP 2015), spatial location (Creamean, Maahn et al. 2018), and vertical height in the atmosphere (Creamean, Maahn et al. 2018; Stohl, Klimont et al. 2013; Xu, Martin et al. 2017). On Alaska's North Slope, black carbon sources can come from international transportation sources (Matsui, Kondo et al. 2011; Stohl 2006; Xu, Martin et al. 2017), biomass burning (Creamean, Maahn et al. 2018; Stohl 2006; Xu, Martin et al. 2017), shipping

(Corbett, Lack et al. 2010; Lack and Corbett 2012), oil and gas exploration and production activities (Creamean, Maahn et al. 2018; Stohl, Klimont et al. 2013), and residential combustion (Stohl, Klimont et al. 2013). In particular, black carbon emitted from shipping can be deposited directly onto sea ice, and ice breakers can deposit black carbon onto the ice pack itself (Brewer 2015). As will be discussed below, black carbon emitted onto ice and snow can increase melting and exacerbate warming as darker and more absorbent land and water surfaces are exposed as a result. With Project construction, black carbon would be emitted as part of the particulate matter less than 2.5 microns in aerodynamic diameter **($PM_{2.5}$)** emissions from diesel-fired equipment, including engines, boilers, heaters, pumping units, and other equipment, including aircrafts and flares.

Black carbon has a strong impact on Arctic regions due to its ability to change the reflective properties of ice and snow. When black carbon is deposited on ice or snow, it darkens the ground, decreasing the reflectiveness of the surface (the albedo) and warming the surface (+0.13 Watts per square meter [W/m^2]). Since black carbon emitted in the Arctic has a higher probability of being deposited onto snow or ice, this "snow- and ice-albedo feedback effect" is stronger when black carbon is emitted in the Arctic than when it is transported from lower latitudes (Sand, Berntsen et al. 2013). Black carbon that is not deposited can increase warming when it absorbs solar radiation in the lower troposphere and boundary layer, decreasing cloud cover and leading to increased melting, further enhancing the snow- and ice-albedo feedback effect as the surface turns from bright snow and ice into darker water. In fact, black carbon has a strong direct radiative effect, meaning it is effective at warming the climate through the direct absorption of radiation and is the component of $PM_{2.5}$ that is most effective at absorbing solar energy. Bond, Doherty et al. (2013) estimate the direct radiative effect of black carbon to be +0.71 W/m^2. Black carbon can also affect the formation of clouds and change their radiative properties, leading to increased warming (+0.23 W/m^2). When black carbon mixes with other pollutants in the atmosphere, a coating can form around the black carbon particle, causing it to grow in size. It is predicted that black carbon particles that have reacted with chemical compounds in this way may have an increased warming effect (Kodros, Hanna et al. 2018).

Black carbon can also cool the climate. When black carbon is lofted high into the atmosphere, it can block solar radiation from reaching the surface in a process called "surface dimming" (Flanner 2013; Sand, Berntsen et al. 2013). Surface dimming also decreases the equatorial-polar temperature gradient, causing less heat to be transported to the Arctic from lower latitudes. Black carbon can also increase reflected incoming solar radiation by increasing high-altitude clouds that reflect solar radiation. Bond et al. (2013) also find that black carbon is co-emitted with other pollutants, and these pollutants can reduce the amount of warming caused by black carbon alone (-0.06 W/m^2).

The effect of black carbon, although expected to be positive overall, is highly variable and dependent on the location and timing of the emissions, the mixing state of the atmosphere, and deposition processes. The complex interactions and feedbacks between black carbon and the environment all contribute to the effect of black carbon on the Arctic climate.

Black carbon would be emitted by sources and activities under Alternative B. For the Project, black carbon emissions were not explicitly quantified; however, black carbon is a component of $PM_{2.5}$ and black carbon emissions are included in $PM_{2.5}$ emissions that are quantified in the air quality analysis (Willow MDP EIS, Section 3.3, *Air Quality*).

3.1.3 Alternative C: Disconnected Infield Roads

Alternative C GHG emissions estimated for the 30-year Project lifetime are provided in the main body of the EIS (Section 3.2.2.3, *Alternative B: Proponent's Project*). Annual average GHG emissions (Table E.2.3) are calculated by dividing the Project's lifetime GHG emissions by the 30-year Project duration. As in the case of Alternative B, GHG emissions in any given year may be higher or lower than annual average GHG emissions (Table E.2.3) because Project activities vary considerably over the life of the Project.

Black carbon would be emitted by sources and activities under Alternative C. Although black carbon is not explicitly quantified, it is a component of $PM_{2.5}$, and $PM_{2.5}$ emissions would be approximately 20% greater under Alternative C than Alternative B. Therefore, it is anticipated that black carbon emissions would also be greater under Alternative C than Alternative B and the effects of black carbon on the environment would increase under Alternative C relative to Alternative B. The annual average emissions shown in Table E.2.3 are for gross GHG emissions and do not account for the market substitution effects discussed in Willow MDP EIS Section 3.2.2.2, *Alternative A: No Action*. The gross emissions over the Project life were calculated using BOEM's GHG Model (BOEM 2019); Appendix E.2B, *Market Substitutions and Greenhouse Gas Downstream Emissions Estimates*). BOEM (2019) also estimated the emissions that the Project would displace considering market effects. The substituted emissions over the Project life are reported in Willow MDP EIS Section 3.2.2, *Environmental Consequences: Effects of the Project on Climate Change*.

Table E.2.3. Annual Average Gross Greenhouse Gas Emissions for Alternative C (thousand metric tons per year)

GHG Emissions	CO_2	CH_4	N_2O	CO_2e (IPCC AR4 100-year GWP)	CO_2e (IPCC AR5 100-year GWP)	CO_2e (IPCC AR5 20-year GWP)
Direct	862	0.319	0.0022	871	872	890
Indirect	7,892	0.433	0.0667	7,923	7,922	7,946
Total[a]	**8,754**	**0.752**	**0.0689**	**8,794**	**8,794**	**8,836**

Note: AR4 (Fourth Assessment Report); AR5 (Fifth Assessment Report); CH_4 (methane); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); GHG (greenhouse gas); GWP (global warming potential); IPCC (Intergovernmental Panel on Climate Change); N_2O (nitrous oxide)
[a] Total values may have small differences due to rounding. Likewise, CO_2e values may be subject to rounding.

3.1.4 Alternative D: Disconnected Access

As mentioned in Section 2.2, *Direct Greenhouse Gas Emissions Calculation Methods*, of this appendix and explained in more detail in Willow MDP EIS Chapter 2.0, *Alternatives*, Alternative D would have a 32-year Project lifetime rather than the 30-year Project lifetime for Alternatives B and C. Alternative D GHG emissions estimated over the 32-year Project lifetime are shown in the main body of the EIS (Section 3.2.2.3, *Alternative B: Proponent's Project*). Project activities vary considerably over the life of the Project and GHG emissions in any given year may be higher or lower than the annual average GHG emissions (Table E.2.4).

Black carbon would be emitted by sources and activities under Alternative D. Although black carbon is not explicitly quantified, it is a component of $PM_{2.5}$ and $PM_{2.5}$ emissions would be greater under Alternative D than Alternative B and emissions under Alternative D would be less than Alternative C. Therefore, it is anticipated that black carbon emissions would be greater under Alternative D than Alternative B but reduced relative to Alternative C. Similarly, the effects of black carbon on the environment described in Willow MDP EIS Section 3.2.1, *Affected Environment*, would increase under Alternative D relative to Alternative B. The annual average emissions shown in Table E.2.4 are for gross GHG emissions and do not account for the market substitution effects discussed in Willow MDP EIS Section 3.2.2.2, *Alternative A: No Action*. The gross emissions over the Project life were calculated using BOEM's GHG Model (BOEM 2019; Appendix E.2B, *Market Substitutions and Greenhouse Gas Downstream Emissions Estimates*). BOEM (2019) also estimated emissions that the Project would displace if market effects were considered. The substituted emissions over the Project life are reported in Willow MDP EIS Section 3.2.2., *Environmental Consequences: Effects of the Project on Climate Change*.

Table E.2.4. Annual Average Gross Greenhouse Gas Emissions for Alternative D (thousand metric tons per year)

GHG Emissions	CO_2	CH_4	N_2O	CO_2e (IPCC AR4 100-year GWP)	CO_2e (IPCC AR5 100-year GWP)	CO_2e (IPCC AR5 20-year GWP)
Direct	769	0.306	0.0018	777	778	795
Indirect	7,404	0.406	0.0625	7,432	7,432	7,454
Total[a]	**8,173**	**0.712**	**0.0643**	**8,210**	**8,210**	**8,249**

Note: AR4 (Fourth Assessment Report); AR5 (Fifth Assessment Report); CH_4 (methane); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); GHG (greenhouse gas); GWP (global warming potential; IPCC (Intergovernmental Panel on Climate Change); N_2O (nitrous oxide)
[a] Total values may have small differences due to rounding. Likewise, CO_2e values may be subject to rounding.

3.1.5 Module Delivery Options

Project lifetime and annual average direct GHG emissions from module transport options alone are shown in Table E.2.5 for Option 1 (Proponent's Module Transfer Island) and Option 2 (Point Lonely Module Transfer Island). Annual average GHG emissions for module transport options are calculated by dividing the Project lifetime GHG emissions by the expected duration of module transport emissions, which is 6 years. Direct GHG emissions from Option 2 are more than twice the emissions from Option 1 because the distance vehicles travel to reach Point Lonely is longer. Total GHG emissions for the Project would be the sum of the selected alternative and the selected module transport option.

Black carbon would be emitted by sources and activities as part of both module transport options. Although black carbon is not explicitly quantified, it is a component of $PM_{2.5}$, and $PM_{2.5}$ emissions would be greater under Option 2 than Option 1. Therefore, it is anticipated that black carbon emissions would also be greater under Option 2 than Option 1, and the effects of black carbon on the environment described in Section 3.1.2.3, *Black Carbon Effects on Climate*, would be greater under Option 2 relative to Option 1.

Table E.2.5. Direct Greenhouse Gas Emissions Associated with Module Transfer Island Options (thousand metric tons)

GHG Emissions	Total CO_2e (IPCC AR4 100-year GWP)	Annual Average CO_2e (IPCC AR4 100-year GWP)	Total CO_2e (IPCC AR5 100-year GWP)	Annual Average CO_2e (IPCC AR5 100-year GWP)	Total CO_2e (IPCC AR5 20-year GWP)	Annual Average CO_2e (IPCC AR5 20-year GWP)
MTI Option 1	151.57	25	151.58	25	151.96	25
MTI Option 2	320.68	53	320.70	53	321.51	54
Difference	169.11	28	169.12	28	169.55	28

Note: AR4 (Fourth Assessment Report); AR5 (Fifth Assessment Report); CO_2e (carbon dioxide equivalent); GHG (greenhouse gas); GWP (global warming potential); IPCC (Intergovernmental Panel on Climate Change); MTI (module transfer island)

3.2 Effects of Climate Change on the Project

Climate change could impact the Project through a variety of ways. Key changes to anticipate as a result of a changing arctic climate include thawing permafrost, shorter ice road seasons, and changes in precipitation. Thawing of the permafrost and uneven settlement could cause damage to infrastructure such as gravel pads, roads, and pipelines. A shorter ice road season can affect transport of materials and personnel that depend on ice roads and thus the impacts due to climate would be more substantial for Alternatives C and D due to the reliance on annual ice roads to connect the Willow project area to existing development (i.e., Greater Mooses Tooth and Alpine developments) during winter. More precipitation could increase surface runoff and the design of gravel surface elevations should consider more extreme precipitation events.

CPAI would accommodate these considerations in their Project design using the following measures:

- Design flow for crossings of North Slope streams would be controlled by breakup flood magnitude, which is significantly larger than summer and fall rain induced flood events.
- Design infrastructure to account for increases in winter precipitation due to climate change that could result in larger spring breakup events due to potentially increased snowfall amounts. Bridge

and culvert designs would account for larger breakup events than river or stream design flow magnitude by providing 4 feet of freeboard above the 100-year floodwater surface elevation (for bridges) and providing a headwater-diameter ratio (Hw/D) of less than 1.0 for a 50-year flood event for culverted stream crossings.

- o Typical bridge design practice in the U.S. per the Federal Highway Administration (FHWA) Project Development and Design Manual is 2 feet of freeboard over the 50-year design water-surface elevatifon.
- o Per FHWA, culverts designed for a "high-standard road" (the most stringent design criteria) are to be designed for a 50-year flow capacity with a Hw/D between 1.2 and 1.5 (Hw/D less than 1.0 means the inlet of the culvert would not be submerged; an Hw/D greater than 1.0 means the culvert inlet would be submerged), depending on culvert size.

For both bridges, the Project's design criteria would be more conservative than FHWA criteria and would be able to accommodate future increases in flows from potential climate change.

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Willow Master Development Plan

Appendix E.2B

Market Substitutions and Greenhouse Gas Downstream Emissions Estimates

Prepared by Bureau of Ocean and Energy Management

Prepared for Bureau of Land Management

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Market Substitutions and Greenhouse Gas Downstream Emissions Estimates for BLM's Willow Master Project

Overview

The Willow Master Environmental Impact Statement (EIS) includes an analysis on climate change that has been drafted with support from the Bureau of Ocean Energy Management (BOEM). BOEM has two models, the Market Simulation Model (MarketSim) and the Greenhouse Gas Lifecycle Model (GHG Model), that were collectively used to help estimate carbon emissions from the consumption of the oil produced from the project, net of the emissions that would have occurred absent the project.

This appendix provides a comparison of the downstream emissions from the Willow Master Project and those from energy sources that would be displaced if the project is implemented (i.e., the emissions that would occur without the project, under the No Action Alternative). BOEM uses MarketSim to estimate the energy sources that could be displaced by the proposed Willow Master Project and then uses the GHG Model to estimate emissions associated with the consumption of both the Willow Master Project production and the displaced energy sources.

The analysis for the Willow Master Project is limited to only the emissions associated with the processing and consumption of the oil from the project and the energy substitutes displaced by the project. The emissions estimates in this analysis do not include any estimated emissions from the actual production of resources from the Willow Master Project or the production or upstream transport of any resources produced through the No Action Alternative (Alternative A).

This appendix first discusses MarketSim and the estimated displaced energy sources with the approval of the Willow Master Project. The GHG Model and the resulting emissions estimates are then described.

BOEM's Market Simulation Model and the Energy Market Substitutions

MarketSim models oil, gas, coal, and electricity markets, and is calibrated to a special run of the National Energy Modeling System by the Energy Information Administration (EIA). The baseline used in MarketSim is a modified version of the EIA's 2018 *Annual Energy Outlook* reference case; the modification involves omission of new OCS lease sales starting in 2019. Removing the EIA's expectation of production from new OCS leasing allows investigation of alternative new OCS leasing scenarios within the EIA's broad energy market projection using MarketSim. MarketSim uses price elasticities derived from EIA and other published elasticity studies to quantify the changes that could occur to prices and energy production and consumption over the time of production.

BOEM developed MarketSim to calculate the energy sources that would replace new offshore oil and natural gas production in the absence of new leases under a National Outer Continental Shelf (OCS) Oil and Gas Leasing Program. These substitute energy sources include additional oil and gas imports, onshore oil and gas production, fuel switching (e.g., using coal instead of oil), and reduced consumption of energy. Energy market substitution occurs due to changes in the feedback loop among supply, demand, and prices.

Using EIA data, MarketSim assumes a baseline supply (production) and demand (consumption) of energy from various sources, as well as their baseline prices and elasticities. That baseline is the No Action Alternative, or a scenario in which none of the project action alternatives would be approved. The model then calculates how introducing production from each action alternative would impact those baseline supply, price, and demand assumptions. Increased oil supply from the project would drive oil prices down, if only slightly. A reduction in oil prices would cause demand for oil to increase even as consumers of energy switched (substituted) from other energy sources like coal, natural gas, or oil from other sources such as imports or domestic onshore/offshore production. Due to this increased demand, the displacement of other sources does not account for 100% of the change from the baseline. The full MarketSim documentation is entitled *Consumer Surplus and Energy Substitutes for OCS Oil and Gas Production: The 2017 Revised Market Simulation Model (MarketSim)*.[1]

Applicability of MarketSim to BLM Decisions

While MarketSim is specifically designed to calculate the energy market substitutes for offshore oil production anticipated from proposed lease offerings, the basic model calculations allow for its use in modeling the substitutes for other oil and gas sources, including new onshore production. Since MarketSim is designed to treat production from new offshore leases as the exogenous variable, modelling substitution effects of new onshore production requires inputting the projected Willow Master production as new offshore oil production. This modelling approach results in a couple of limiting assumptions, including the following:

- Additional onshore production from the Willow Master Project essentially generates the same types of energy market substitutes as offshore production.
- The model will not include displacement of production from new offshore leases as a result of new Alaska onshore production. The model does assume some displacement of existing offshore production (i.e., for areas currently under lease).

Even with these limiting assumptions, BOEM believes that MarketSim reasonably approximates the displacement of energy market substitutes by production from the onshore project. Further, the emissions analysis used for this EIS only considers the mid- and downstream emissions. That is, only the emissions from refining and consumption activities are included in the analysis. Given that scope, the specific substitutions of onshore production, offshore production, or imports are not important in the overall emissions analysis conducted for the Willow Master EIS, as that analysis is driven by the substitution of oil, gas, or coal. A version of MarketSim is being adapted to BLM’s needs and will be used for future energy market substitution analyses.

MarketSim Modeling Assumptions

The production schedule used to analyze the three alternatives is shown in Table 1.

Table 1: Willow Master Development Plan Project Alternative Production Schedules

Alternative	Production (barrels)	Start Year	End Year
Alternative B	590,907,672	2024	2050
Alternative C	591,057,007	2024	2050
Alternative D	591,435,688	2026	2052

Note: Alternative A is the No Action Alternative—rejection of Alternatives B through D.

MarketSim Results

MarketSim provided estimates of the energy sources displaced with development of the Willow Master Project, and that is how they are described in this appendix. Conversely, these same energy substitutions as the energy market sources that would displace foregone oil production from the Willow Master Project if the proposal were not approved.

[1] Industrial Economics, Inc. 2017. *Consumer surplus and energy substitutes for OCS oil and gas production: the 2017 revised Market Simulation Model (MarketSim)*. U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2017-039. Available at: https://www.boem.gov/ESPIS/5/5612.pdf.

MarketSim estimates the different types of substitute fuels as well as the origin of the fuel (i.e., onshore, offshore, or imports). These details are then used to model the upstream impacts associated with the production of offshore energy and substitute sources. However, for this study, only the mid- and downstream emissions were estimated. Thus, only the type of substituted fuel is required, as the location of substitute production is not necessary.

Table 2 shows the proportional displacement of energy substitutes that would be displaced by Willow Master Project oil production under each of the three action alternatives (Alternatives B through D). For example, under Alternative B, 93.68% of the oil production from Willow Master would displace oil from other sources (oil that would have been produced from other domestic projects or imported), 2.04% of the production would displace natural gas, 0.63% would displace coal production, and 0.39% would displace biofuels and electricity from other sources. The remaining forecasted production represents increased demand over the baseline.

As shown in Table 2, approval of the proposed project would lead to an increase in oil consumption (totaling about 5.42% of the Willow Master production), coupled with a smaller decrease in consumption of other energy sources. The net effect on overall energy consumption is that it would be slightly higher with Willow Master production than under the No Action Alternative (i.e., the status quo without the project). The increase in demand is estimated to be the energy equivalent of about 3.26% of Willow Master production. Under all three action alternatives, more than 96% of the anticipated production would displace other carbon-emitting fuel sources.

Table 2: Displaced Fuels and Increased Demand

Percent of Willow Master Oil that:	Alternative B	Alternative C	Alternative D
*Displaces Oil	93.68%	93.68%	93.70%
*Displaces Natural Gas	2.04%	2.04%	2.09%
*Displaces Coal	0.63%	0.63%	0.57%
Displaces Biofuels and Electricity from other sources	0.39%	0.39%	0.39%
Represents New Demand (Not Displacing other sources)	3.26%	3.26%	3.25%
Oil	5.42%	5.42%	5.43%
Natural Gas	-1.47%	-1.47%	-1.49%
Coal	-0.22%	-0.22%	-0.21%
Electricity	-0.47%	-0.47%	-0.47%

Notes: Emissions are calculated for displaced oil, natural gas, and coal. Alternative A is the No Action Alternative—rejection of the Proposed Action. MarketSim treats the No Action Alternative as a baseline; therefore, the results for each of the action alternatives are relative to Alternative.

The *percentage* of substitutions for Alternatives B and C are identical, even though there is a slight difference in the *amount* of production. However, Alternative D has slightly different substitution percentages, which are driven by the different years over which the oil would be produced. The underlying EIA data differ by year, and the impacts would similarly vary given the year of additional production. This is noticeable in the substitution of coal, which is less heavily displaced in Alternative D because the EIA projects that coal will compose a slightly smaller proportion of the U.S. energy composition in the later years.

GHG Model

The GHG Model was developed to estimate emissions that could be anticipated as a result of the consumption of new offshore oil and natural gas production. For the Willow Master Project, the GHG

Model is used to estimate emissions from oil and gas refining, processing, storage, and consumption, as well as the emissions associated with energy market substitutes in the absence of oil production from the proposed project (i.e., the No Action Alternative). The full GHG Model documentation is entitled *OCS Oil and Natural Gas: Potential Lifecycle Greenhouse Gas Emissions and Social Cost of Carbon.*[2]

Adaptation of the GHG Model

The GHG Model calculates the impacts of consumption of oil, gas, and coal and is not specific to the origin (domestic onshore, domestic offshore, or imports) of the oil consumed. As such, it is appropriate for use in calculating the greenhouse gas emissions from the consumption of oil and gas from the Willow Master Project.

To reiterate, onsite emissions (i.e., emissions associated with the production of the oil and natural gas) are not calculated in this analysis. To estimate these onsite emissions, a separate model designed to analyze GHG emissions from the onshore equipment and facilities would be required. Further, the upstream transportation emissions from displaced sources are not included. For example, the fairly significant emissions associated with transportation of imported oil by tanker to the U.S. under the No Action Alternative are not considered.

Since publishing the above-cited technical documentation, the annual emissions from refineries and natural gas processing and storage systems have been updated, along with updates to reflect oil and gas consumption patterns in the United States as of 2018.

GHG Model Results

The GHG Model estimates only the emissions from the mid- and downstream activities for both the project production and the displaced energy sources. Only the emissions from displaced oil, natural gas, and coal are modeled. Emissions from biofuels are not included, and electricity from other sources is assumed to have no emissions from the mid- and downstream. The results of the GHG Model are shown in Tables 3, 4, and 5. The lower prices for oil and other energy sources associated with increased U.S. production as a result of the Willow Master project would affect both domestic and foreign energy consumption. However, currently neither BOEM nor BLM has the ability to estimate differences in GHG emissions caused by changes in foreign consumption. This estimation would require detailed data on proportional consumption changes and the most likely energy substitutions, as well as on emissions from refineries, natural gas systems, coal processing, and other emission factors specific to the energy substitutes for all countries worldwide.

As shown in Table 2, oil from the Willow Master Project would displace other sources of oil, natural gas, and coal production, resulting in more oil and coal consumption and less natural gas consumption than under the No Action Alternative. Given that natural gas has a similar methane (CH_4) emissions factor, and coal has a higher CH_4 emissions factor compared to oil, CH_4 emissions from the displaced substitutes are higher than under any of the three action alternatives (i.e., Alternative B through D). However, because oil has far higher carbon dioxide (CO_2) emissions factor compared to natural gas, the overall CO_2 equivalent (CO_{2e}) displaced is lower than the amount forecasted with production from the Willow Master Project.

[2] Wolvovsky, E. and Anderson, W. 2016. *OCS Oil and Natural Gas: Potential Lifecycle Greenhouse Gas Emissions and Social Cost of Carbon.* BOEM OCS Report 2016-065. 44 pp. Available at: https://www.boem.gov/OCS-Report-BOEM-2016-065/.

Table 3: Downstream Greenhouse Gas Emissions Estimates for each Willow Master Production Action Alternative (thousands of metric tons)

Alternative	CO_{2e}	CO_2	CH_4	N_2O
B: Proponent's Project	237,626	236,708	13	2
C: Disconnected Infield Roads	237,686	236,767	13	2
D: Disconnected Access	237,838	236,919	13	2

Key: CH_4 (methane); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); N_2O (nitrous oxide)

Table 4: Downstream Estimates of Displaced Greenhouse Gas Emissions for each Willow Master Development Plan Production Action Alternative (thousands of metric tons)

Alternative	CO_{2e}	CO_2	CH_4	N_2O
B: Proponent's Project	225,157	224,187	16	2
C: Disconnected Infield Roads	225,214	224,243	16	2
D: Disconnected Access	225,173	224,202	16	2

Key: CH_4 (methane); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); N_2O (nitrous oxide)

Table 5: Net Emissions from the Willow Master Development Plan Production (thousands of metric tons)

Alternative	CO_{2e}	CO_2	CH_4	N_2O
B: Proponent's Project	12,469	12,521	-3	0
C: Disconnected Infield Roads	12,472	12,524	-3	0
D: Disconnected Access	12,665	12,717	-3	0

Key: CH_4 (methane); CO_2 (carbon dioxide); CO_2e (carbon dioxide equivalent); N_2O (nitrous oxide)

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Willow Master Development Plan

Appendix E.3
Air Quality Technical Appendix

August 2019

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List of Tables

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List of Acronyms

AAAQS	Alaska Ambient Air Quality Standards
AQRV	air quality related values
CAP	criteria air pollutant
CASTNET	Clean Air Status and Trends Network
CPAI	ConocoPhillips Alaska, Inc.
dv	deciview
EPA	Environmental Protection Agency
FLM	Federal Land Manager
HAP	hazardous air pollutant
^{o}F	degrees Fahrenheit
kg N/ha/year	kilograms nitrogen per hectare per year
kg S/ha/year	kilograms sulfur per hectare per year
km	kilometers
MACT	maximum achievable control technology
m/s	meters per second
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NH_4^-	ammonium
NO_2	nitrogen dioxide
NO_3^-	nitrate
NOx	nitrogen oxides
NPR-A	National Petroleum Reserve in Alaska
NTN	National Trends Network
NWS	National Weather Service
$PM_{2.5}$	particulate matter less than 2.5 microns in aerodynamic diameter
PM_{10}	particulate matter less than or equal to 10 microns in aerodynamic diameter
Project	Willow Master Development Plan Project
PSD	Prevention of Significant Deterioration
RHR	Regional Haze Rule
SO_2	sulfur dioxide
SO_4^{2-}	sulfate

1.0 AIR QUALITY

The Environmental Protection Agency (EPA) has determined that 50 kilometers (km) (31 miles) is sufficient to determine whether an emissions source will cause or contribute to exceedances of ambient air quality standards and is the approved distance for regulatory near-field air quality models (40 CFR 51, Appendix W). The far-field (regional) modeling domain is more than 300 km (186 miles) from the Willow Master Development Plan Project (Project) in all directions except for south of the Project, where the closest point is approximately 250 km (155 miles).

1.1 Affected Environment

1.1.1 Regulatory Framework

In Alaska, EPA has delegated authority to the Alaska Department of Environmental Conservation for the implementation and enforcement of the Alaska Air Quality Control Regulations (18 AAC 50) through an EPA approved state implementation plan. The Alaska Ambient Air Quality Standards (AAAQS) were promulgated in 18 AAC 50.010. The National Ambient Air Quality Standards (NAAQS) and AAAQS are provided in Table E.3.1.

Table E.3.1. National and Alaska Ambient Air Quality Standards

Pollutant[a]	Averaging Time	NAAQS[b] Primary	NAAQS[b] Secondary	AAAQS[c,d]	Form
CO	8 hours	9 ppm	NA	10 mg/m^3	Not to be exceeded more than once per year
CO	1 hour	35 ppm	NA	40 mg/m^3	Not to be exceeded more than once per year
NO_2	1 hour	100 ppb	NA	188 µg/m^3	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
NO_2	Annual	53 ppb	53 ppb	100 µg/m^3	Annual mean, not to be exceeded
O_3	8 hours	0.070 ppm	0.070 ppm	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
$PM_{2.5}$	Annual	12 µg/m^3	15 µg/m^3	12 µg/m^3	Annual mean, averaged over 3 years
$PM_{2.5}$	24 hours	35 µg/m^3	35 µg/m^3	35 µg/m^3	98th percentile, averaged over 3 years
PM_{10}	24 hours	150 µg/m^3	150 µg/m^3	150 µg/m^3	Not to be exceeded more than once per year on average over three years
SO_2	1 hour	75 ppb	NA	196 µg/m^3	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
SO_2	3 hours	NA	0.5 ppm	1,300 µg/m^3	Not to be exceeded more than once per year
SO_2	24 hours	NA	NA	365 µg/m^3	Not to be exceeded more than once per year
SO_2	Annual	NA	NA	80 µg/m^3	Annual mean, not to be exceeded

Note: AAAQS (Alaska Ambient Air Quality Standards); CO (carbon monoxide); mg/m^3 (milligrams per cubic meter); NA (not applicable); NAAQS (National Ambient Air Quality Standards); NO_2 (nitrogen dioxide); O_3 (ozone); $PM_{2.5}$ (particulate matter less than 2.5 microns in aerodynamic diameter); PM_{10} (particulate matter less than or equal to 10 microns in aerodynamic diameter); ppb (parts per billion); ppm (parts per million) SO_2 (sulfur dioxide); µg/m^3 (micrograms per cubic meter).
[a] Lead and ammonia are not shown as they are not pollutants of concern in the Project area.
[b] 40 CFR 50
[c] 18 AAC 50.010
[d] All Alaska Ambient Air Quality Standards are primary, except for 3-hour SO_2.

EPA designates geographic areas demonstrating compliance with the NAAQS as "attainment," while areas that exceed the NAAQS are designated as "nonattainment." If there is insufficient data to designate an area as "attainment" or "nonattainment," the area will be designated as "unclassifiable." The analysis area for air quality is designated as "attainment/unclassifiable" for all criteria air pollutants (CAP).

The closest Class I area to the Project is Denali National Park, which is located more than 700 km (435 miles) south of the Project and is not in the analysis area for air quality. Class II areas within the far-field analysis area for air quality are Gates of the Arctic National Park, Noatak National Preserve, and the Arctic National Wildlife Refuge (Figure E.3.1). The Class II Prevention of Significant Deterioration (PSD) increments are presented in Table E.3.2.

Table E.3.2. Prevention of Significant Deterioration Increments for Class II Areas

Pollutant	Averaging Time	Class II PSD Increment (μg/m^3)	Form
NO_2	Annual	25	Annual mean, not to be exceeded
SO_2	3 hours	512	Not to be exceeded more than once per year
SO_2	24 hours	91	Not to be exceeded more than once per year
SO_2	Annual	20	Annual mean, not to be exceeded
$PM_{2.5}$	24 hours	9	Not to be exceeded more than once per year
$PM_{2.5}$	Annual	4	Annual mean, not to be exceeded
PM_{10}	24 hours	30	Not to be exceeded more than once per year
PM_{10}	Annual	17	Annual mean, not to be exceeded

Source: 40 CFR 52.21

Notes NO_2 (nitrogen dioxide); $PM_{2.5}$ (particulate matter less than 2.5 microns in aerodynamic diameter); PM_{10} (particulate matter less than or equal to 10 microns in aerodynamic diameter); PSD (prevention of significant deterioration); SO_2 (sulfur dioxide); μg/m^3 (micrograms per cubic meter).

The air quality related values (AQRV) are resources that may be affected by a change in air quality (National Park Service 2011). The Federal Land Managers' (FLM) Air Quality Related Values Work Group identifies AQRVs as "visibility or a specific scenic, cultural, physical, biological, ecological, or recreational resource identified by the FLM for a particular area" (USFS, NPS et al. 2010).

Visibility is a measure of how far and well we can see into the distance and is sensitive to changes in air quality. Visibility impairment, or haze, occurs when sunlight is absorbed or scattered by tiny particles (e.g., sulfates [SO_4^{2-}], nitrates [NO_3^-]) and gases (e.g., nitrogen dioxide [NO_2]) (EPA 2017). The absorption and scattering of light impairs visibility conditions (i.e., visual range, contrast, and coloration). Haze-causing pollutants can be directly emitted or can be formed through the reaction of precursor gases emitted into the atmosphere (e.g., formation of SO_4^- from sulfur dioxide [SO_2]). The Regional Haze Rule (RHR) was promulgated in 1999 to improve and protect visibility in Class I areas (40 CFR 51.308). The RHR defines reasonable progress goals to improve visibility on the most impaired days and ensure no degradation on the least impaired days with the goal of attaining natural conditions (i.e., estimated visibility conditions in the absence of man-made air pollution) in each Class I area by 2064. Under the RHR, visibility is quantified using the deciview (dv) haze index, which is derived from light extinction. An incremental change in dv corresponds to a uniform and incremental change in visual perception for the entire range of visibility conditions. Single-source impacts on visibility are assessed by comparing the 98th percentile of the source contribution to the haze index to defined thresholds. A source that exceeds 0.5 dv (approximate 5% change in light extinction) is considered to contribute to visibility impairment, while a source that exceeds 1.0 dv (approximate 10% change in light extinction) is considered to cause visibility impairment (USFS, NPS et al. 2010).

Atmospheric deposition can negatively affect ecosystems and other AQRVs. Dry deposition is continuous while wet deposition can only occur in the presence of precipitation. Potential deposition impacts include, but are not limited to, acidification of soils and waterbodies and nutrient enrichment (USFS, NPS et al. 2010). Wet or dry deposition of acidic pollutants formed from emitted SO_2 and nitrogen oxides (NOx) is referred to as acid rain (EPA 2018b). There are currently no federal standards for atmospheric deposition, but FLMs use critical loads and deposition analysis thresholds for assessing both cumulative impacts and source specific impacts from new or modified PSD sources, respectively. A critical load is the level of deposition below which no harmful effects to an ecosystem are expected. Deposition analysis thresholds are screening thresholds that define the additional amount of deposition within an FLM area below which impacts are considered negligible.

The National Emission Standards for Hazardous Air Pollutants defines maximum achievable control technology (MACT) standards that are technology-based standards for each regulated source category. MACT is applicable to all major sources (potential to emit more than 10 tons per year of a single hazardous air pollutant [HAP] or 25 tons per year of any combination HAPs) and to some area sources (any stationary source of HAPs not classified as a major source) in specific source categories.

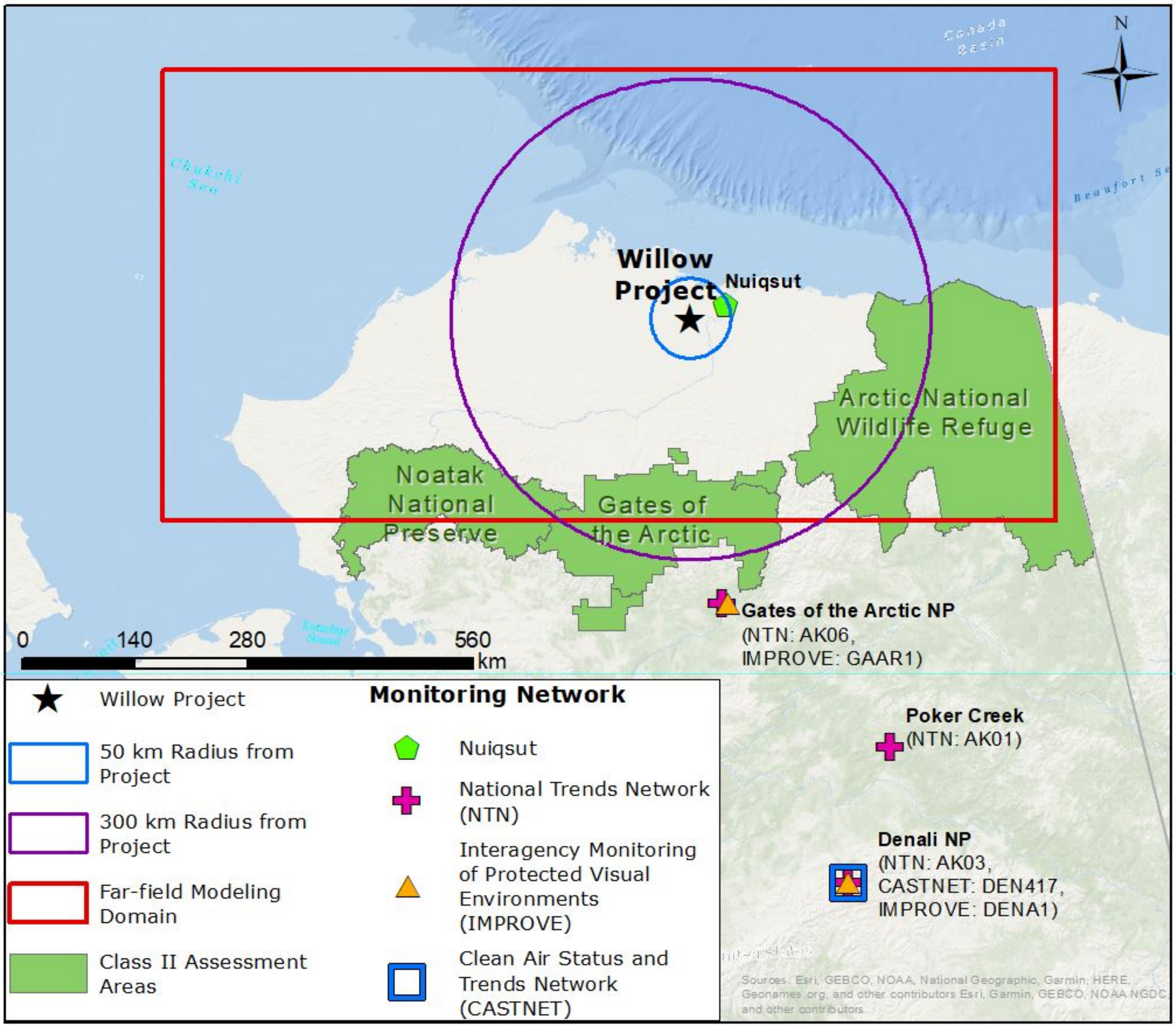


Figure E.3.1. Analysis Areas for Air Quality and Ambient Air Quality Monitors, Class II Areas, and the Far-Field (Regional) Modeling Domain

1.1.2 Characterization of Existing Air Quality in the Analysis Area

Regional air quality is affected by a variety of factors including climate, meteorology, and the magnitude and location of air pollutant sources. This section provides descriptions of the regional climate and meteorology, and existing regional sources of air pollution that affect air quality in the analysis area. Existing air quality in the analysis area is assessed through a review of recent ambient air quality monitoring data and AQRVs.

1.1.2.1 Climate and Meteorology

The Project is located on the North Slope within the National Petroleum Reserve in Alaska (NPR-A). Several monitoring stations were used to characterize climate and meteorology in the analysis area. Monthly average precipitation and temperature data were acquired from National Oceanic and Atmospheric Administration National Weather Service (NWS) stations at Umiat, Kuparuk, Utqiaġvik (Barrow), and Nuiqsut (Figure E.3.2). A monitoring station operated by ConocoPhillips Alaska, Inc. (CPAI) was used to characterize prevailing wind patterns.

Table E.3.3 provides summaries of average monthly temperature and precipitation from the NWS stations shown in Figure E.3.2. The annual average temperature in the NPR-A is approximately 10 degrees

Fahrenheit (°F) with monthly average maximum temperatures below freezing from October to May (BLM 2012). The coldest temperatures (usually in February) range from -10°F to -15°F at the maximum and -25°F to -30°F at minimum on average (Table E.3.3). Summer temperatures rise above freezing with the highest temperatures typically occurring in July. The average maximum and minimum temperatures in July range from 45°F to 65ºF and 35°F to 40ºF, respectively.

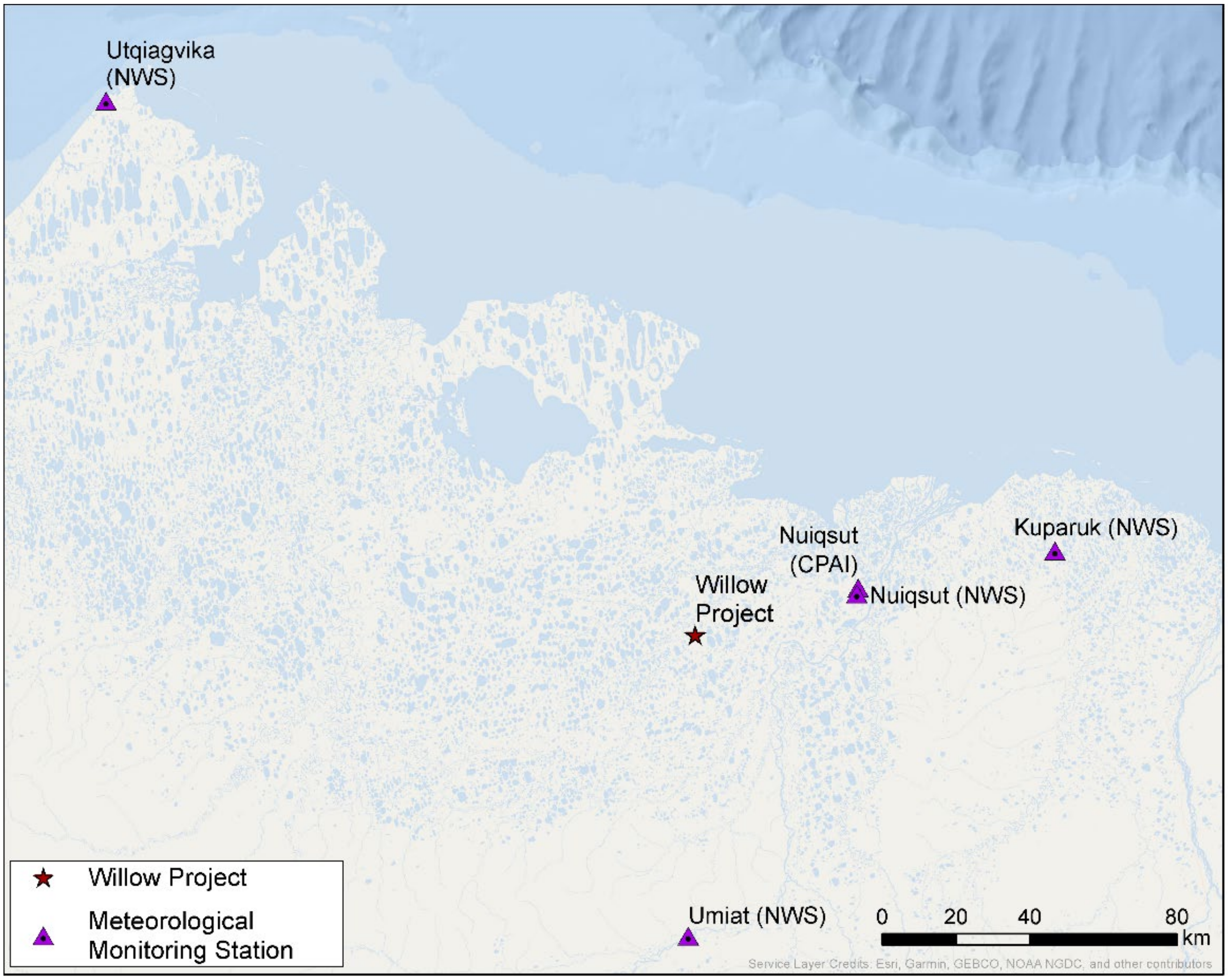


Figure E.3.2. Monitoring Stations used to Characterize Climate and Meteorology in the Project Area

Precipitation in the analysis area is low with Nuiqsut receiving 2.74 inches of precipitation on average per year (Table E.3.3). Precipitation is highest during summer with over three-fourths of the total annual precipitation falling between June and September. Though snowfall is sparser during the summer months, it can occur during any month with the highest average snowfall rates occurring in October. There is generally snow on the ground from October to May (BLM 2012).

Table E.3.3. Monthly Climate Summary Data at Monitoring Stations in the Air Quality Analysis Area

Utqiaġvik (Barrow)[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average Max. Temperature (ºF)	-7.4	-10.6	-7.9	7.0	24.7	38.9	45.8	43.3	34.9	20.7	5.8	-4.4	15.9
Average Min. Temperature (ºF)	-19.9	-22.7	-20.6	-6.8	15.3	30.1	34.1	34	28.2	11.6	-5.4	-16.2	5.1
Average Total Precipitation (in)[b]	0.18	0.17	0.13	0.18	0.17	0.34	0.91	1.02	0.68	0.49	0.25	0.17	4.67
Average Total Snowfall (in)	2.4	2.7	2.0	2.8	2.3	0.6	0.3	0.7	4.0	7.7	4.3	2.8	32.5
Average Snow Depth (in)	9	10	11	11	7	1	0	0	1	4	7	8	6
Kuparuk[a]	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Average Max. Temperature (ºF)	-11.3	-10.9	-8.4	8.7	28.1	47.4	56	50.8	39.2	21.5	4.0	-4.7	18.4
Average Min. Temperature (ºF)	-23.9	-24.0	-22.6	-6.3	17.0	33.0	39.0	36.9	28.9	10.9	-8.9	-17.8	5.2
Average Total Precipitation (in)[b]	0.13	0.17	0.08	0.14	0.07	0.32	0.87	1.06	0.48	0.35	0.16	0.13	3.96
Average Total Snowfall (in)	2.6	2.5	2.2	2.8	1.7	0.5	0.0	0.3	3.0	8.4	4.6	3.5	32.0
Average Snow Depth (in)	9	9	9	10	5	0	0	0	0	3	6	7	5
Umiat[a]	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Average Max. Temperature (ºF)	-12.7	-13.8	-6.7	11.5	32.4	57.5	66.2	57.7	41.4	18.2	-0.7	-11.9	19.9
Average Min. Temperature (ºF)	-28.9	-31.2	-26.8	-11.0	15.7	37.0	42.5	37.2	26.1	2.4	-16.8	-28.0	1.5
Average Total Precipitation (in)[b]	0.38	0.26	0.16	0.21	0.07	0.68	0.79	1.06	0.47	0.68	0.38	0.33	5.46
Average Total Snowfall (in)	4.5	2.4	2.3	1.9	1.2	0.2	0.0	0.2	2.6	8.5	5.2	4.2	33.2
Average Snow Depth (in)	14	16	17	17	9	0	0	0	0	5	9	12	8
Nuiqsut	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
Average Max. Temperature (ºF)[c]	-7.1	-9.6	-8.4	10.0	29.6	51.1	58.2	51.6	40.1	21.8	5.1	-2.5	20
Average Min. Temperature (ºF)[c]	-22.9	-23.3	-21.5	-6.0	18.2	35.4	41.6	38.7	31.5	14.2	-8.7	-15.7	6.8
Average Total Precipitation (in)[b,d]	0.08	0.05	0.02	0.18	0.19	0.27	0.74	0.88	0.38	0.04	0.05	0.13	2.74

Notes: °F (degrees Fahrenheit); in (inches); Max. (maximum); Min. (minimum)
[a] National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) data, obtained from Western Regional Climate Center (https://wrcc.dri.edu/summary/Climsmak.html). Period of record: Utqiaġvik (1901 to 2016); Umiat (1945 to 2001); Kuparuk (1983 to 2016). Historical records are under Utqiaġvik's former name of Barrow.
[b] Units of total precipitation are inches of liquid water equivalent.
[c] NOAA NWS data obtained from NOAA National Centers for Environmental Information (https://www.ncdc.noaa.gov/cdo-web/datatools/normals). Period of record: 1981 to 2010.
[d] NOAA NWS data, obtained from U.S. Department of Agriculture Natural Resources Conservation Service (http://agacis.rcc-acis.org/?fips=02185). Period of record: 1998 to 2017.

The wind rose in Figure E.3.3 shows the distribution of wind direction and speeds measured at the CPAI Nuiqsut monitoring station, located approximately 46 km (28.5 miles) east-northeast of the Project, from 2013 to 2017. The prevailing wind direction at Nuiqsut was from the northeast with wind speeds averaging 5 meters per second (m/s) (11 miles per hour). The maximum observed wind speed was 22.4 m/s (50 miles per hour) and calm winds were infrequent, occurring for less than 1% of hours during the 5-year period. Figures E.3.4 through E.3.7 provide seasonal wind patterns for winter, spring, summer, and fall seasons, respectively, for the 5-year period.

Management Arctic Air Quality Modeling Study (Fields Simms, Billings et al. 2014). Existing emissions from onshore sources (e.g., oil and gas production and exploration, airports, pipelines, non-oil and gas related stationary and mobile sources) comprise the majority of the total existing emissions, and emissions from offshore sources (e.g., drilling rigs, survey/drilling vessels and aircraft, commercial vessels) are small in comparison (Fields Simms, Billings et al. 2014). Overall, onshore oil and gas sources comprise the largest fraction of existing emissions for all CAPs except particulate matter less than or equal to 10 microns in aerodynamic diameter (PM_{10}) and particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$) for which dust from unpaved roads comprises the largest fraction (Fields Simms, Billings et al. 2014). The major existing sources of HAPs in the region are onshore oil and gas, other nonroad vehicles and equipment, on-road vehicles, and waste incineration, landfills, and other combustion sources.

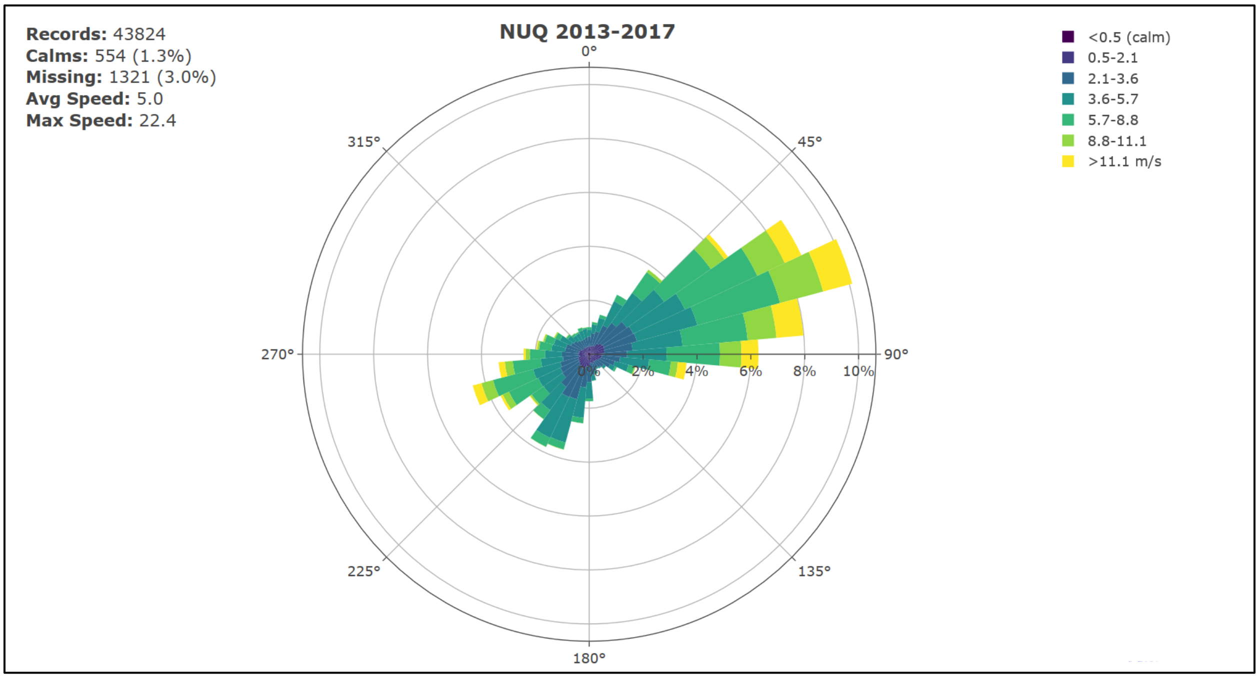


Figure E.3.3. Annual Wind Rose Data from the ConocoPhillips Alaska, Inc. Nuiqsut Monitoring Station for the Period of 2013 to 2017

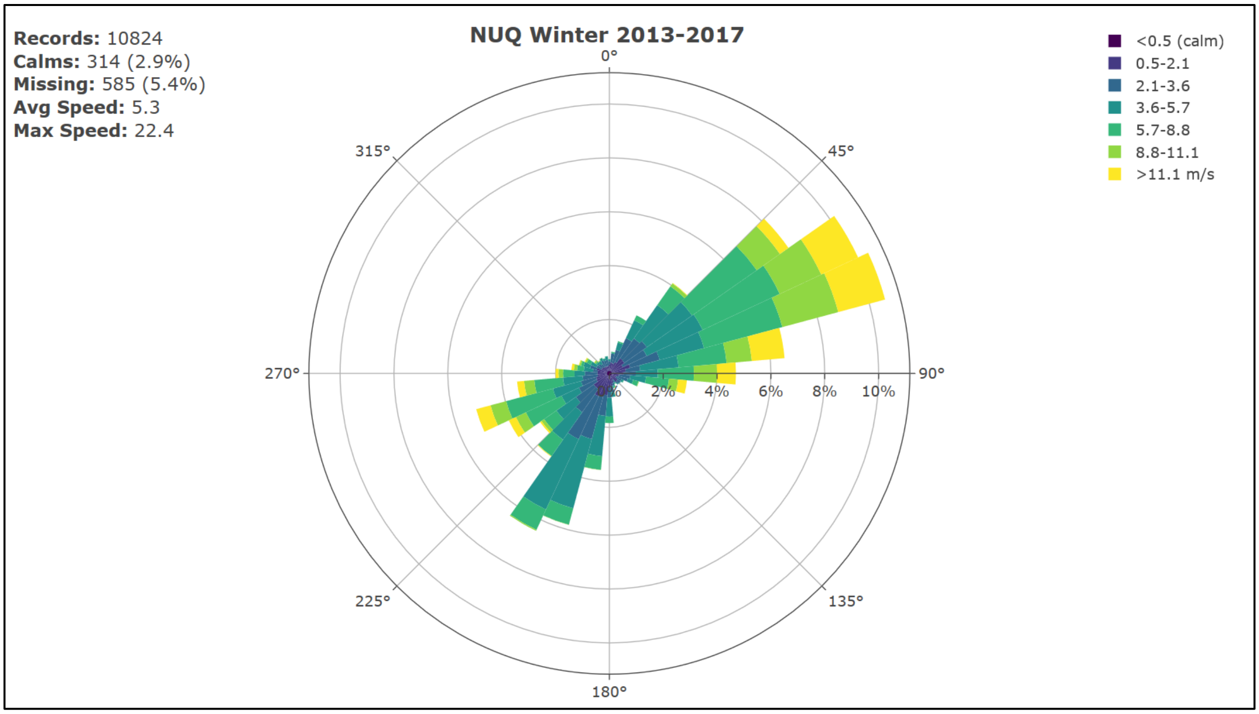


Figure E.3.4. Wind Rose Data from the ConocoPhillips Alaska, Inc. Nuiqsut Monitoring Station for Winter Months (December, January, February) from 2013 to 2017

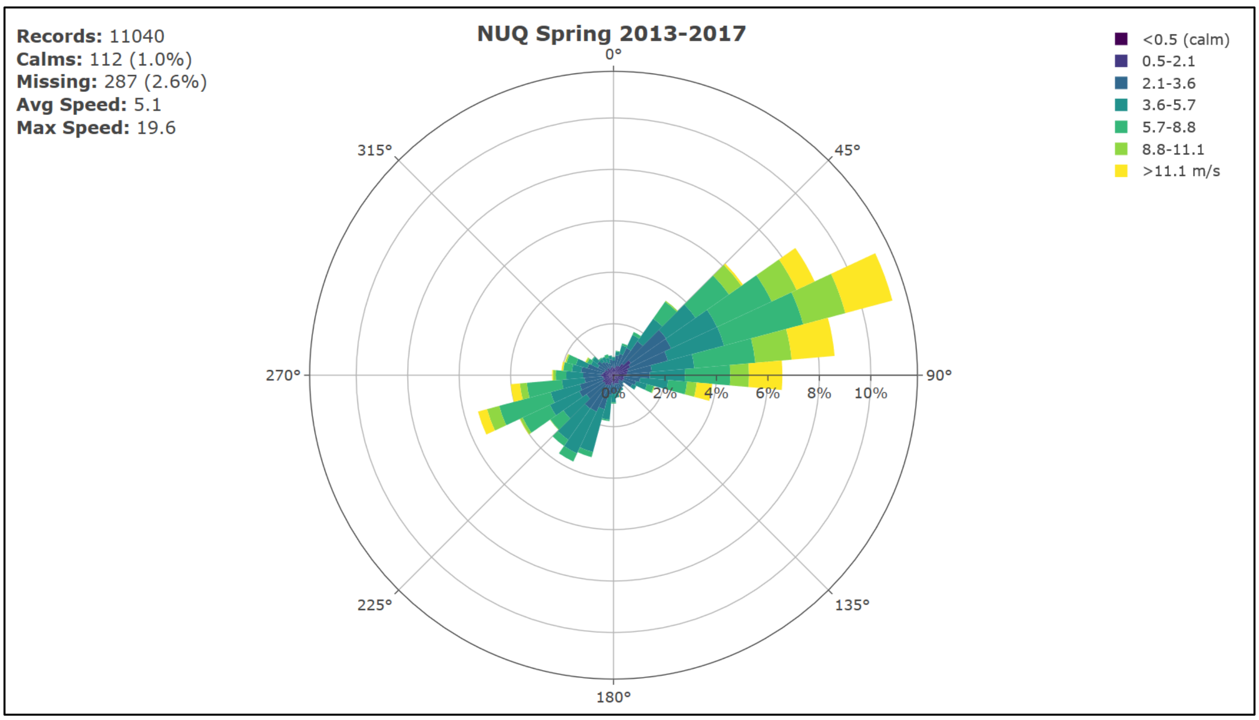


Figure E.3.5. Wind Rose Data from the ConocoPhillips Alaska, Inc. Nuiqsut Monitoring Station for Spring Months (March, April, May) from 2013 to 2017

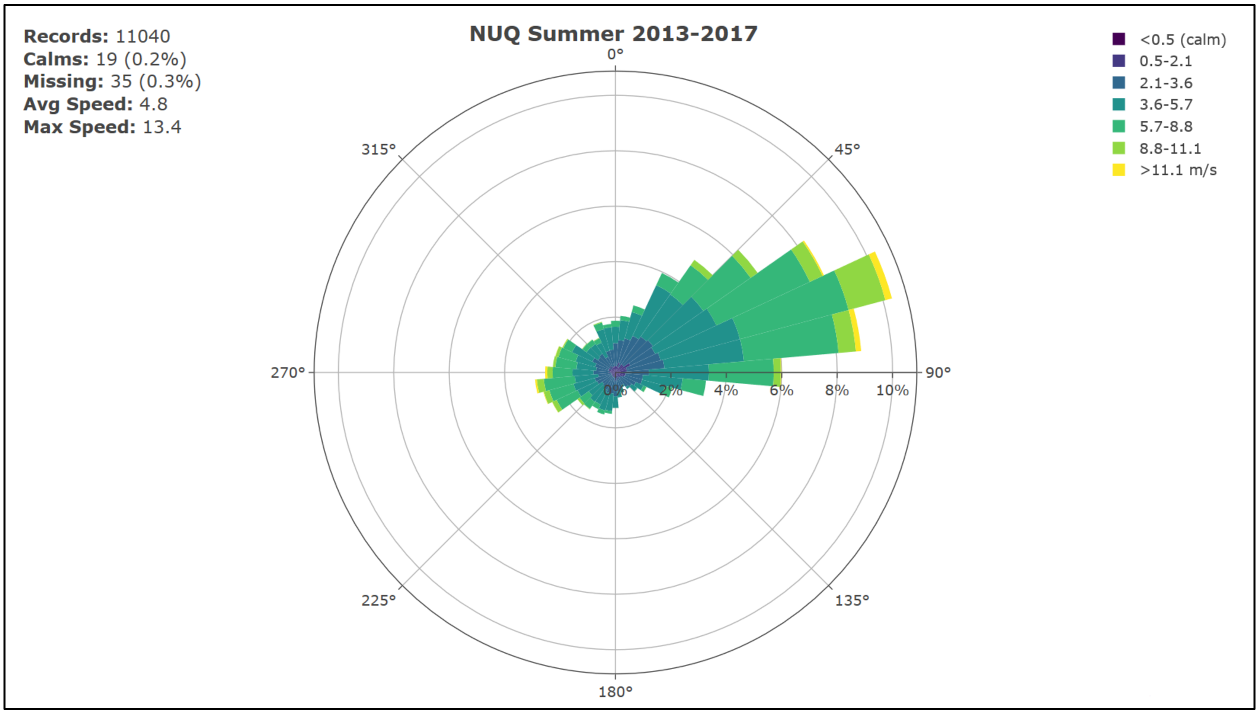


Figure E.3.6. Wind Rose Data from the ConocoPhillips Alaska, Inc. Nuiqsut Monitoring Station for Summer Months (June, July, August) from 2013 to 2017

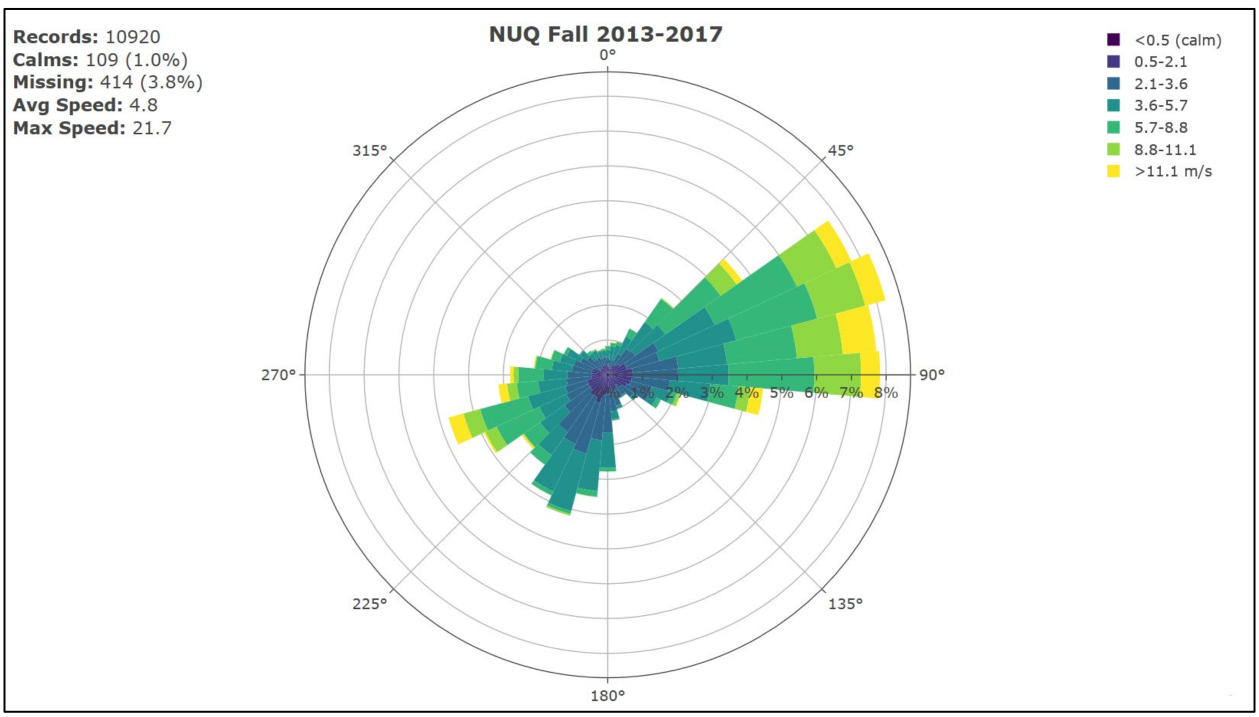


Figure E.3.7. Wind Rose Data from the ConocoPhillips Alaska, Inc. Nuiqsut Monitoring Station for Fall Months (September, October, November) from 2013 to 2017

1.1.2.2 Existing Regional Sources of Air Pollution

A summary of existing regional emissions for the North Slope and adjacent waters (Beaufort Sea and Chukchi Sea Planning Areas) is available from the 2012 baseline scenario of the Bureau of Ocean Energy Air Quality Monitoring

1.1.2.3 Criteria Air Pollutants

The Nuiqsut Monitoring Station is operated by CPAI and is the most representative station in the region of the Project (Figure E.3.1) (BLM 2018). Monitoring data from the CPAI Nuiqsut monitor are provided in Table E.3.4 for 2015 through 2017. All CAPS are monitored except for lead, for which there are no monitoring sites in the analysis area. The monitored concentrations are all well below the NAAQS. This is consistent with the existing air quality of the larger analysis area that is designated as "attainment/unclassifiable" for all CAPs.

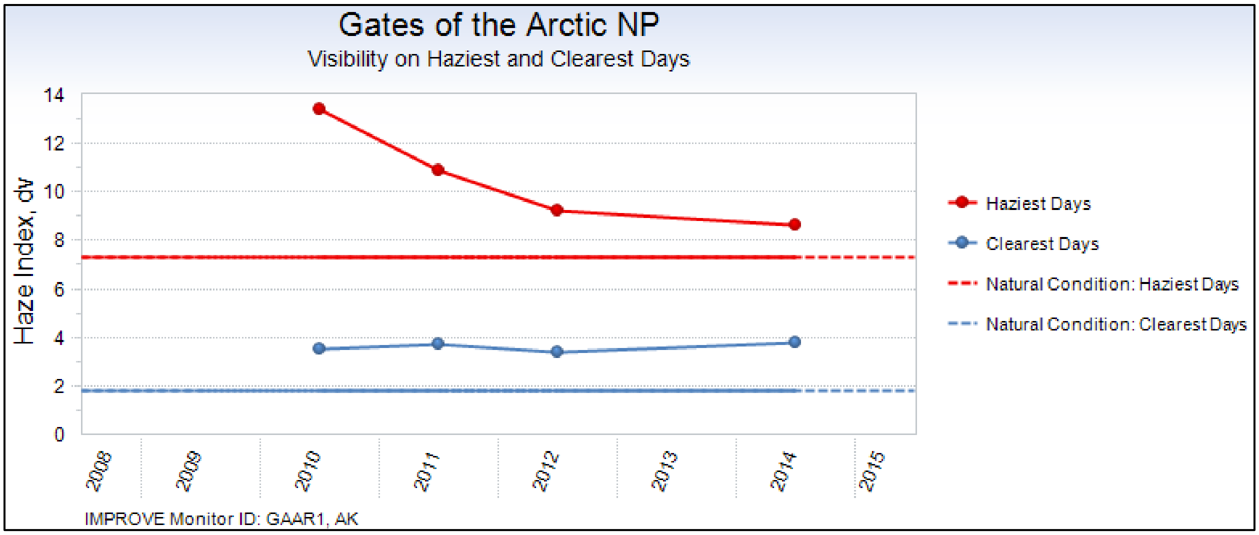
Table E.3.4. Measured Criteria Air Pollutant Concentrations at the Nuiqsut Monitoring Station

Pollutant (units)	Averaging Period	Rank	2015	2016	2017	Avg.	NAAQS/ AAAQS	Below NAAQS/ AAAQS?
CO (ppm)	1 hour	2nd highest daily max	1	1	1	1	35	Yes
CO (ppm)	8 hours	2nd highest daily max	1	1	1	1	9	Yes
NO_2 (ppb)	1 hour	99th percentile of daily max	23.6	18.0	27.4	23.0	100	Yes
NO_2 (ppb)	Annual	Annual average	2	1	2	2	53	Yes
SO_2 (ppb)	1 hour	99th percentile of daily max	1.2	3.2	3.5	2.6	75	Yes
SO_2 (ppb)	3 hours	2nd highest daily max	1.2	3.4	3.5	2.7	500	Yes
SO_2 (ppb)	24 hours	2nd highest	1.1	3.1	3.4	2.5	139	Yes
SO_2 (ppb)	Annual	Average	0.1	0.8	0.9	0.6	31	Yes
PM_{10} (μg/m^3)	24 hours	2nd highest	98.5	128.8	48.8	92.1	150	Yes
$PM_{2.5}$ (μg/m^3)	24 hours	98th percentile	10.0	5.5	6.9	7.5	35	Yes
$PM_{2.5}$ (μg/m^3)	Annual	Average	2.8	1.3	1.6	1.9	12	Yes
O_3 (ppb)	8 hours	4th highest daily max	46	43	45	44	70	Yes

Notes: AAAQS (Alaska Ambient Air Quality Standards); CO (carbon monoxide); max (maximum); NAAQS (National Ambient Air Quality Standards); NO_2 (nitrogen oxides); PM_{10} (particulate matter less than or equal to 10 microns in aerodynamic diameter); $PM_{2.5}$ (particulate matter less than 2.5 microns in aerodynamic diameter); ppb (parts per billion); ppm (parts per million); SO_2 (sulfur dioxide); μg/m^3 (micrograms per cubic meter). NAAQS/AAAQS for ozone (O_3) were converted from parts per million to parts per billion, and sulfur dioxide (SO_2) 24-hour and annual standards were converted from micrograms per cubic meter to parts per billion.

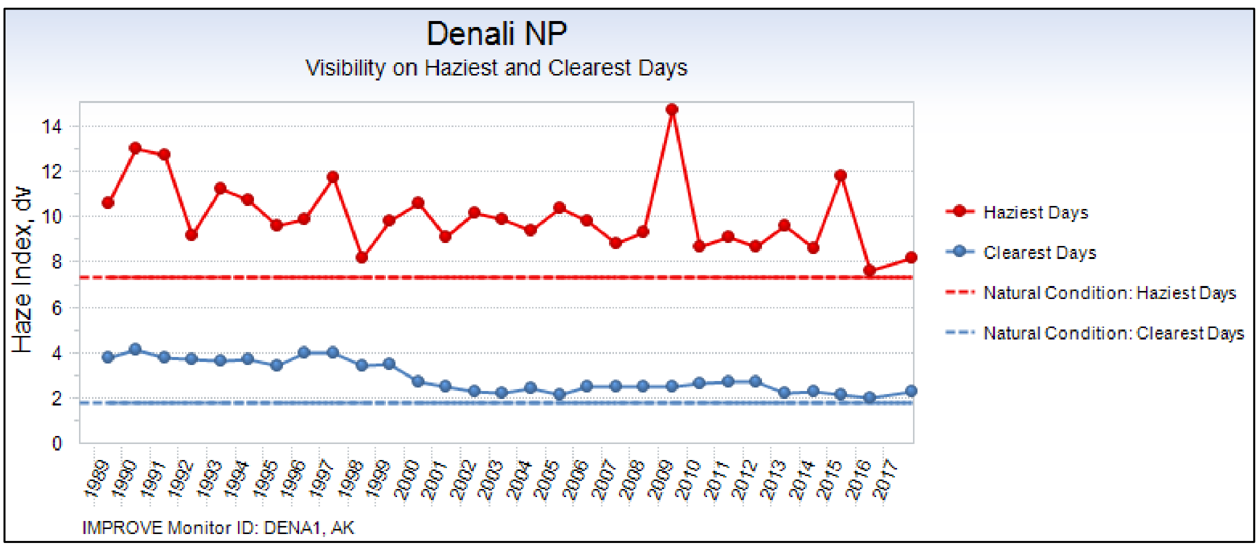
1.1.2.4 Visibility

Visibility and air pollutant concentration data is collected by Interagency Monitoring of Protected Visual Environments at monitoring sites close to Class I areas across the country. The two closest monitors to the Project are Gates of the Arctic National Park and Denali National Park (Figure E.3.1). Data from these monitors are presented in Figures E.3.8 and E.3.9. Denali National Park is outside of the analysis area for air quality but is included here as it is the closest Class I area. Data are shown for the 20% haziest and 20% clearest days along with the corresponding natural visibility conditions. Under natural conditions, the haze index is below 2 dv on the clearest days and 7.5 dv on the haziest days at both locations corresponding to a visual range of 319 km (198 miles) and 184 km (114 miles), respectively. The haze index on the haziest days generally shows a downward trend with the maximum value of approximately 13 dv and 15 dv (visual range of about 85 km [53 miles] to 100 km [62 miles]) occurring in 2009 and 2010 at Denali National Park and Gates of the Arctic National Park, respectively. On the clearest days, the haze index in Denali National Park has consistently been slightly higher than natural conditions since 2000 ranging from approximately 2 to 3 dv (visible range of 319 km [198 miles] to 288 km [179 miles]), while in Gates of the Arctic National Park, the haze index on the clearest days has been consistently around 4 dv (visible range of 261 km [162 miles]) since monitoring began in 2010.



(Source: views.cira.colostate.edu/fed)

Figure E.3.8. Visibility Data for Gates of the Arctic National Park



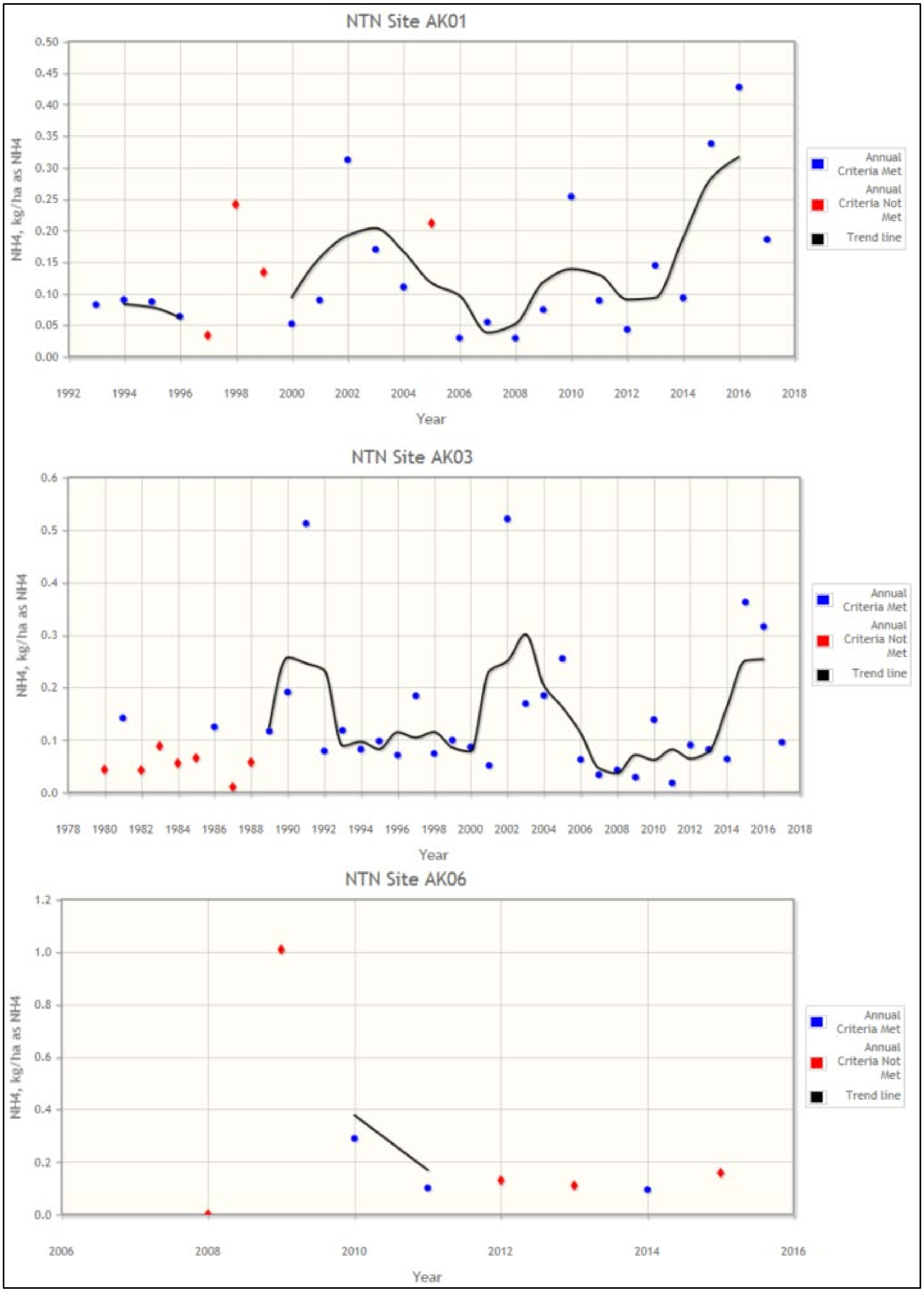
(Source: views.cira.colostate.edu/fed)

Figure E.3.9. Visibility Data for Denali National Park

1.1.2.5 Acid Deposition

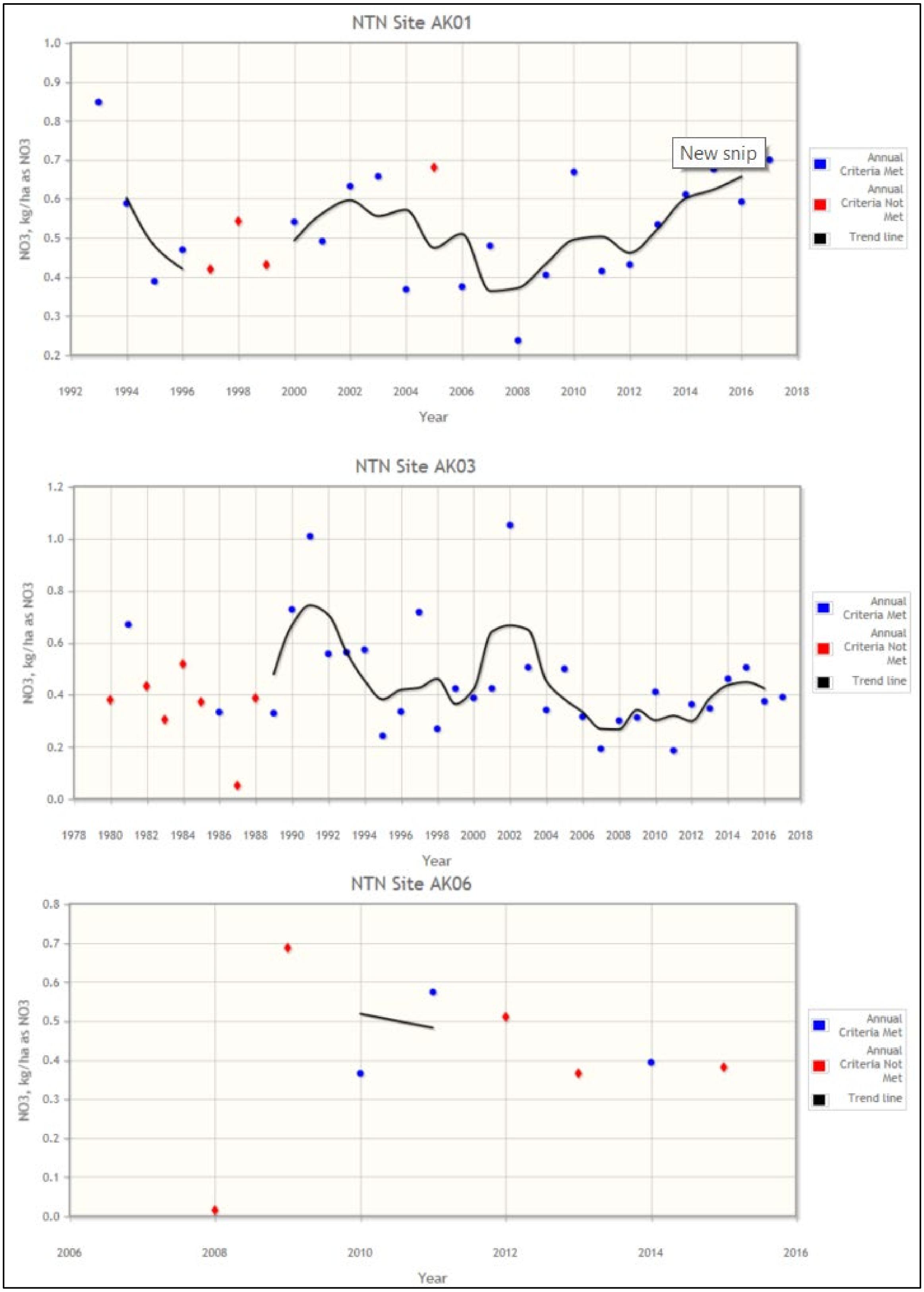
The National Trends Network (NTN) of the National Atmospheric Deposition Program (NADP) has monitoring stations throughout the U.S. that monitor precipitation chemistry and measure wet deposition (National Atmospheric Deposition Program 2018). The closest active monitoring stations to the Project are at Gates of the Arctic National Park (NTN Site AK06), Poker Creek (NTN Site AK01), and Denali National Park (NTN Site AK03) as shown in Figure E.3.1. The Toolik Field Station (NTN Site AK96) began collecting data in acid deposition in 2017, but no validated data were available at the time of this analysis. Trends in monitored wet deposition fluxes of ammonium (NH_4^-), NO_3^-, and SO_4^{2-} at each site are provided in Figures E.3.10, E.3.11, and E.3.12, respectively. The blue dots on the graphs indicate yearly concentrations which had met the annual completeness criteria, while the red dots indicate which yearly concentrations had not met the annual completeness criteria. Trendlines are also shown in black and represent a 3-year moving average where the minimum data completeness criteria are met for that 3-year period. The wet deposition fluxes of NH_4^-, NO_3^-, and SO_4^{2-} are small at all monitors (most annual values below 1.0 kilogram per hectare per year) with no apparent trend in most cases. However, the wet deposition fluxes of NH_4^- at Poker Creek and Denali National Park, and NO_3^- at Denali National Park, have shown an upward trend in recent years.

The NADP also provides estimates of total (wet and dry) sulfur and nitrogen deposition for critical load analysis and other ecological studies using a hybrid approach with modeled and monitoring data (National Atmospheric Deposition Program 2014). Wet deposition data from NTN along with air concentration data from networks such as the Clean Air Status and Trends Network (CASTNET) is used (EPA 2018a). The estimated total deposition flux of nitrogen and sulfur is provided in Figure E.3.13 for Denali National Park for 1999 through 2017, which is the only monitor in Alaska with recent CASTNET data (DEN417 in Figure E.3.1). The highest monitored total deposition fluxes of nitrogen and sulfur occurred in 2002 and were 0.741 kilograms nitrogen per hectare per year (kg N/ha/year) and 0.601 kilograms sulfur per hectare per year (kg S/ha/year), respectively. The mean deposition fluxes of nitrogen and sulfur are 0.285 kg N/ha/year and 0.287 kg S/ha/year, respectively. The total deposition flux of nitrogen was well below critical load defined by the FLMs for the tundra ecoregion of Alaska (1.0 to 3.0 kg N/ha/year) in all years.



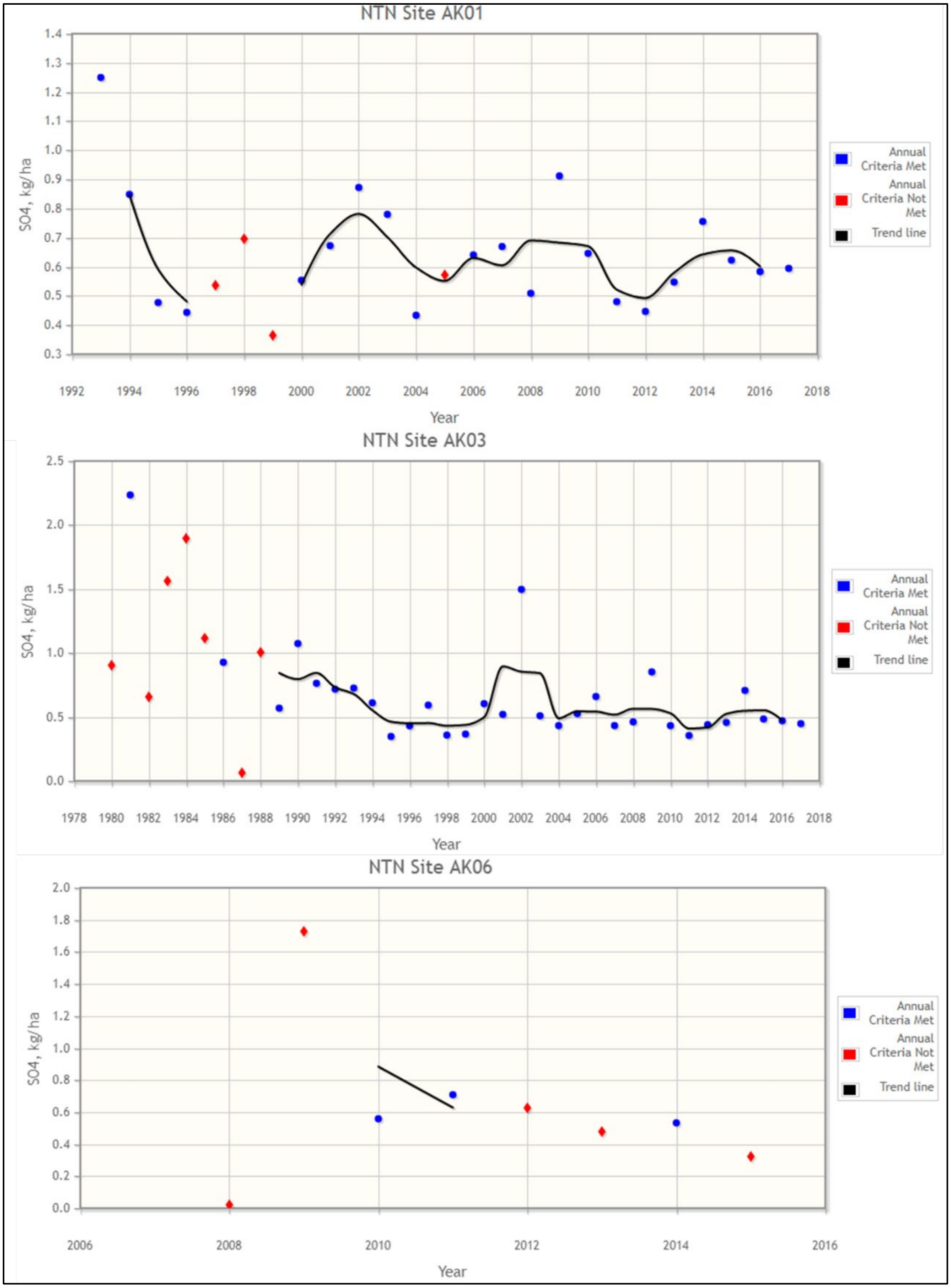
(Source: NADP 2018)

Figure E.3.10. Trends in Wet Deposition of Ammonium at Poker Creek (NTN Site AK01), Denali National Park (NTN Site AK03), and Gates of the Arctic National Park (NTN Site AK06)



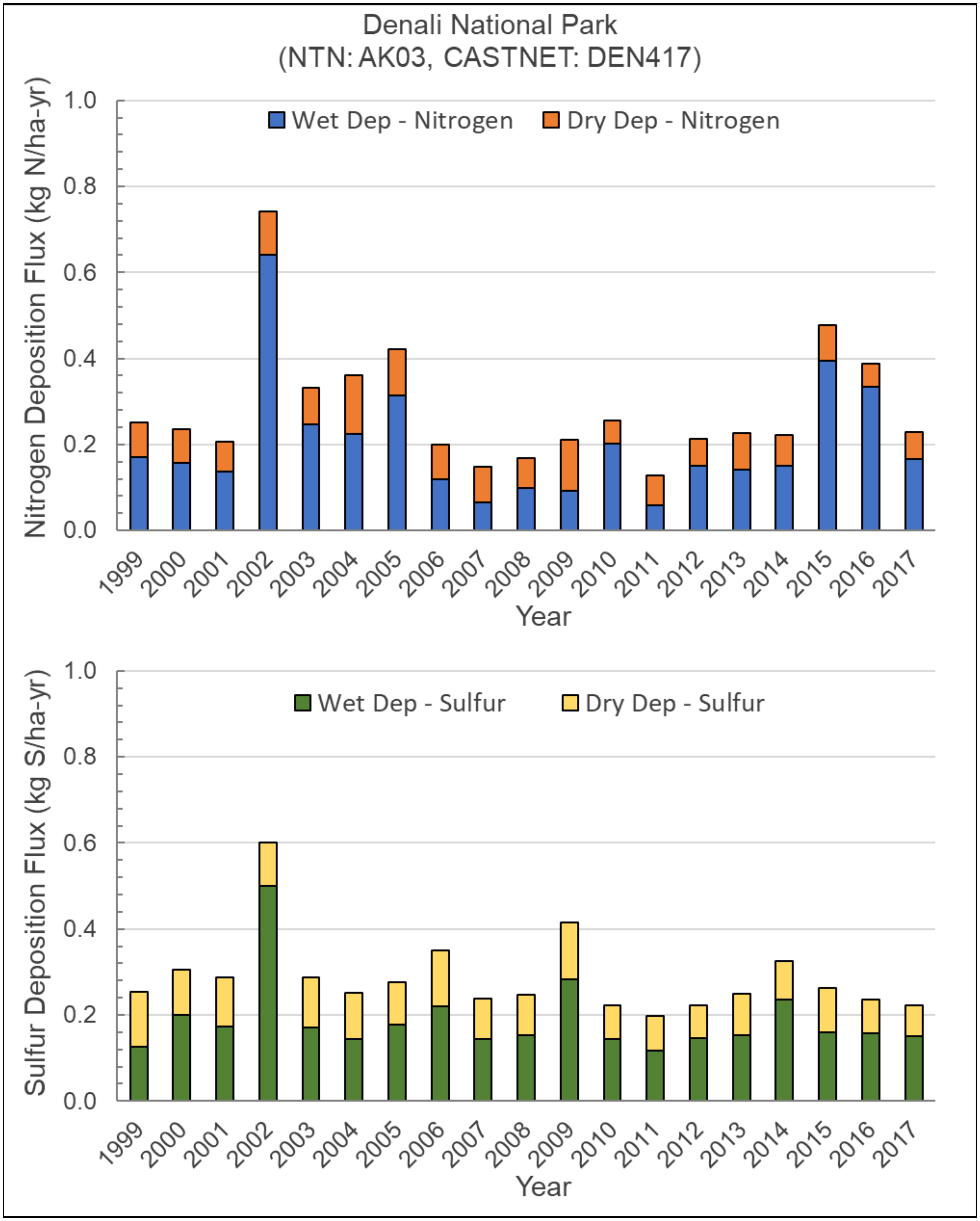
(Source: NADP 2018)

Figure E.3.11. Trends in Wet Deposition of Nitrate at Poker Creek (NTN Site AK01), Denali National Park (NTN Site AK03), and Gates of the Arctic National Park (NTN Site AK06)



(Source: NADP 2018)

Figure E.3.12. Trends in Wet Deposition of Sulfate at Poker Creek (NTN Site AK01), Denali National Park (NTN Site AK03), and Gates of the Arctic National Park (NTN Site AK06)



(Source: EPA 2018)

Figure E.3.13. Total Nitrogen and Sulfur Deposition Flux at Denali National Park

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Attachments for
Appendix E.3
Air Quality Technical Appendix

The following attachments are available upon request:

Attachment A	Near-field Source Locations and Modeled Emission Rates
Attachment B	Willow MDP CAMx Model Performance Evaluation
Attachment C	ConocoPhillips Alaska Incorporated's Alternative B Emissions Inventory Report (Proponent's Proposed Action)
Attachment D	Air Quality Impacts from the Module Transfer Island

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Willow Master Development Plan

Appendix E.4
Soils, Permafrost, and Gravel Resources Technical Appendix

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Glossary Terms

Dust shadow – The area of deposition by airborne dust around gravel infrastructure.

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1.0 SOILS, PERMAFROST, AND GRAVEL RESOURCES TECHNICAL INFORMATION

1.1 Comparison of Alternatives

Table E.4.1 summarizes effects to soils, permafrost, and gravel resources by action alternative and module delivery option.

Table E.4.1. Impacts to Soils, Permafrost, and Gravel Resources by Action Alternative and Module Transport Option

Species	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Acres of gravel fill	442.7	487.8	410.7	NA	NA
Volume of gravel fill (cubic yards)	4,700,000	5,400,000	5,100,000	397,000	446,000
Acres of **dust shadow**[a]	3,466.6	3,514.8	2,700.2	NA	NA
Acres of freshwater ice infrastructure	2,872.3	3,400.3	4,451.2	1,355.3	2,753.2
Number of culvert batteries	11	10	8	NA	NA
Number of cross-drainage culverts	202	194	149	NA	NA
Number of VSMs	8,918	9,048	8,851	NA	NA

Note: NA (not applicable); VSM (vertical support member)

[a] Area potentially altered by dust generated from vehicles or wind on gravel fill extending 328 feet (100 meters) from gravel infrastructure; Alternatives B, C, and D include full mine site development.

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Appendix E.5
Contaminated Sites Technical Appendix

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List of Acronyms

Project	Willow Master Development Plan Project

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1.0 CONTAMINATED SITES TECHNICAL INFORMATION

1.1 Assessment Criteria and Methodology

The potential for the Willow Master Development Plan Project (Project) to encounter contamination from existing sites was evaluated using records of existing contaminated sites and spills within 0.5 miles of the Project to identify the locations, characteristics, and quantities of existing contamination. The locations of existing contamination were evaluated against the Project activities to assess the likelihood of encountering contamination. The likelihood of encountering contamination during Project construction was assessed using a rating system of very low to high. Ratings are a function of spill status (cleanup complete or active) and distance of the site from the Project footprint. Table E.5.1 presents the assessment criteria for contaminated sites.

Table E.5.1. Contaminated Sites Assessment Criteria

Location	Active	Cleanup Complete or Cleanup Complete with Institutional Controls
Within 100 feet of Project activity	Moderate	Low
Between 100 and 500 feet of Project activity	Low	Very low
Greater than 500 feet of Project activity	Very low	Very low

1.2 Contaminated Site Details

Table E.5.2 provides a summary of contaminated sites within 0.5 mile of the Project (Figure 3.5.1).

Table E.5.2. Contaminated Sites within 0.5 mile of the Project

Hazard ID	Site Name	Event Year	Status	Distance to Project Activity (miles)	Likelihood of Encountering
2923	Lonely AFS Dewline - Diesel Tank SS10	1995	Cleanup complete	0.00	Low
2924	Lonely AFS Dewline - Beach Diesel SS003	1995	Cleanup complete	0.2	Very low
2925	Lonely AFS Dewline - Hangar Pad SS13	1995	Cleanup complete	0.0	Very low
2926	Lonely AFS Dewline - Landfill LF007	1995	Cleanup complete	0.0	Low
2927	Lonely AFS Dewline - Diesel Spills SS05	1995	Cleanup complete	0.0	Moderate
2928	Lonely AFS Dewline - POL Storage SS04	1995	Cleanup complete	0.0	Low
2932	Lonely AFS Dewline - Garage SS09	1995	Cleanup complete	0.0	Very low
2933	Lonely AFS Dewline - Landfill LF011/SS006	1995	Cleanup complete	0.1	Very low
2934	Lonely AFS Dewline - Sewage Disposal SS01	1995	Cleanup complete	0.2	None[a]
2935	Lonely AFS Dewline - Drum Storage SS02	1995	Cleanup complete	0.1	None[b]
2936	Lonely AFS Dewline - Module Train SS012	1995	Cleanup complete	0.0	Low
4223	Lonely AFS Dewline - AOC 1, 2, & 3	2005	Cleanup complete	0.0	Very low

Source: ADEC 2019

Note: AFS (Air Force site); POL (petroleum, oil, and lubricant); AOC (area of concern).

[a] Site 2934 was noted by the Alaska Department of Environmental Conservation as having eroded into the Beaufort Sea in August 2008.

[b] Site 2935 was noted by the Alaska Department of Environmental Conservation as having eroded into the Beaufort Sea in April 2015.

2.0 REFERENCES

ADEC. 2019. "Contaminated Sites Program Databases." Accessed February 20, 2019. https://dec.alaska.gov/Applications/SPAR/PublicMVC/CSP/Search.

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Appendix E.6
Noise Technical Appendix

There is no technical appendix for this resource

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Appendix E.7
Visual Resources Technical Appendix

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Appendix E.7A Visual Resources Technical Appendix
Appendix E.7B Visual Contrast Rating Worksheets

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List of Acronyms

BLM	Bureau of Land Management
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
VCRW	Visual contrast rating worksheets
VRI	Visual Resource Inventory
VRM	Visual Resources Management

Glossary Terms

Background zone - Areas visible within 5 to 15 miles from **key observation points**.

Distance zones - The level of visibility and distances from important viewer locations, including travel routes, human use areas, and observation points. Distance zones consist of foreground-middleground (0 miles to 5 miles), background (5 to 15 miles), and seldom-seen (not visible or beyond 15 miles). The Willow Master Development Plan Project's (Project's) estimated nighttime lighting conditions are determined by the heights of drill rigs and communications towers. The Project would be visible out to 30 miles, based on the direct line-of-sight limits due to the curvature of the earth and regional atmospheric conditions.

Foreground-middleground one - Areas visible within less than 5 miles from key observation points.

Key observation points - One or a series of points on a travel routes or at a use area or potential use area. This includes points with views of the Project that were identified based on areas of high visual sensitivity, angle of observation, number of viewers, public access, length of time the Project is in view, relative Project size, season of use, and light conditions.

Scenic quality - The relative worth of a landscape from a visual perception point of view expressed as a quantitative measure of qualitative criteria associated with landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications (BLM 2012).

Seldom-seen zone - Areas within the foreground-middleground and background zones that are not visible, or areas that are visible but are beyond the background zone (more than 15 miles from key observation points).

Sensitivity level - The measure of public concern for scenic quality (as determined through the VRI process).

Viewshed - The total landscape seen from a point, or from all or a logical part of a travel route, use area, or water body.

Visual resources - Visible physical features on a landscape, including land, water, vegetation, animals, structures, and other features.

Visual Resource Inventory - The process of determining the visual value of BLM-administered lands through the assessment of the scenic quality rating, sensitivity level, and distance zones of **visual resources** within those lands.

Visual Resource Inventory classes - Four visual resource inventory classes, which all BLM-administered lands are placed into based on scenic quality, sensitivity levels, and distance zones, as determined through the VRI process.

Visual Resources Management classes - Categories assigned to public lands based on scenic quality, sensitivity level, and distance zones with consideration for multiple-use management objectives. There are four classes; each class has an objective that prescribes the amount of change allowed in the characteristic landscape. VRM classes are assigned through BLM Resource Management Plans (which is the Integrated Activity Plan for the NPR-A).

1.0 VISUAL RESOURCES

1.1 Visual Resources Management in the National Petroleum Reserve in Alaska

The following descriptions, worksheets, and tables support the analysis in the Willow MDP EIS, Section 3.7, *Visual Resources*, and tier to previous Bureau of Land Management (BLM) studies. Chapter 3.7 discusses existing conditions in Section 3.7.1, *Affected Environment*, and discloses impacts to scenery and people, and conformance with BLM Visual Resources Management (VRM) objectives (BLM 2012) in Section 3.7.2, *Environmental Consequences*. The BLM **Visual Resource Inventory** (VRI) (BLM 2012) provides the visual baseline conditions using the indicators of scenic quality, sensitivity, and distance zones. The BLM scenic quality rating is the basis for determining impacts to scenery in the analysis area. The BLM sensitivity levels and distance zones are the basis for determining impacts to people (human environment) in the analysis area.

The referenced figures and tables in this appendix contain quantitative and qualitative information for:

1. **Scenic quality** is the relative worth of a landscape from a visual perception point of view expressed as a quantitative measure of qualitative criteria associated with landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.
2. **Sensitivity level** is the measure of public concern for scenic quality (as determined through the VRI process).
3. **Distance zones** are the level of visibility and distances from important viewer locations, including travel routes, human use areas, and observation points. Distance zones consist of the **foreground-middleground** (0 miles to 5 miles), background (5 to 15 miles), and **seldom-seen** (not visible or beyond 15 miles) zones. The Willow Master Development Plan Project's (Project's) estimated nighttime lighting conditions are determined by the heights of drill rigs and communications towers which would be visible out to 30 miles, based on the direct line-of-sight limits due to the curvature of the earth and regional atmospheric conditions.
4. **VRI classes** are four visual resource inventory classes which all BLM-administered lands are placed into based on scenic quality, sensitivity levels, and distance zones, as determined through the VRI process.
5. **VRM classes** are categories assigned to public lands based on scenic quality, sensitivity level, and distance zones with consideration for multiple-use management objectives. There are four classes. Each class has an objective that prescribes the amount of change allowed in the characteristic landscape. VRM classes are assigned through BLM Resource Management Plans, which for the National Petroleum Reserve in Alaska (NPR-A) is the Integrated Activity Plan (BLM 2012).

The BLM's VRM class objectives are defined in Table E.7.1.

Visual contrast rating worksheets (VCRW), located in Appendix E.7B below, document:

1. The forms, lines, colors, and textures of landforms/water, vegetation, and structures in the characteristic landscape.
2. The forms, lines, colors, and textures of landforms/water, vegetation, and structures of the project.
3. The visual contrasts in the categories are strong, moderate, weak, and none; conformance with VRM objectives; and recommended mitigations, if any.

Table E.7.1. Bureau of Land Management Visual Resources Management Class Objectives

Class	Management Objective
Class I	The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
Class II	The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
Class III	The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
Class IV	The objective of Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.

Source: BLM 1986

The Project's VCRWs are included in Appendix E.7B and include:

- VCRW-1: Contrast Ratings and Conformance for Foreground-Middleground Viewing Situations in VRM Class IV Areas
- VCRW-2: Contrast Ratings and Conformance for Background and Seldom-Seen Viewing Situations in VRM Class IV Areas
- VCRW-3: Contrast Ratings and Conformance in VRM Class II Areas

1.2 The Willow Project and Visual Resources Analysis Area

The analysis area for visual resources is the area within line-of-sight from ground-eye-level to the tallest components of the Project (drill rig and communications tower lighting). For this Project, that area (also known as the **viewshed**) is 30 miles and includes the 0- to 5-mile **foreground-middleground zone** and the 5- to 15-mile **background zone** (Figure 3.7.1). The Project viewshed includes all areas from which the proposed facilities would be visible based on topographical obstruction and distance.

1.3 Bureau of Land Management Scenic Quality in the Project Viewshed

The BLM scenic quality classes are the basis for determining impacts to scenery in the analysis area. Due to the natural character of existing conditions in the viewshed, the Project would be strongly contrasting with scenery. The Project's impacts to scenery are determined by comparing the view characteristics of the action alternatives with views of the characteristic landscape, where existing Class A (high quality) and Class B (moderate quality) scenery would be more susceptible to contrasts and impacts than would Class C scenery. The Project would result in substantial changes in the visual landscape for public land users and viewers in the foreground-middleground and background distance zones and the level of change and scenic quality would reduce the inventoried scenery class designations in the viewshed. Table E.7.2 shows the acreages and percentages of scenic quality classes where viewers would have visibility toward the Project. The scenic quality classes are shown in Figure 3.7.2, and the Project's viewshed is shown in Figure 3.7.1.

Table E.7.2. Scenic Quality Classes in the Analysis Area and Viewshed

Area	Class A Acres (%)	Class B Acres (%)	Class C Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	185,287.0 (3.4%)	29,980.6 (0.5%)	2,424,891.4 (43.9%)	2,885,632.00 (52.2%)	**5,524,791 (100%)**
In Project viewshed	170,063.4 (3.8%)	14,625.8 (0.3%)	1,791,064.6 (39.9 %)	2,517,298.20 (56%)	**4,493,052 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have scenic quality classifications.

1.4 Bureau of Land Management Sensitivity Levels and Distance Zones in the Project Viewshed

The BLM sensitivity level and distance zones are the basis for determining impacts to people/viewers in the analysis area. Higher user concern for scenery would be more susceptible to visual impacts than lower concern and near distance zones would be more susceptible to visual impacts than far distance zones. Visual contrasts for viewers are determined by comparison of the view characteristics of the Project with views of the characteristic landscape. The Project would result in strong visual contrasts and viewer impacts that are strong in comparison with existing conditions, including visually dominant forms, lines, colors, and textures of landforms, water, vegetation, and structures. The Project would result in strong contrasts to scenic quality for viewers in the foreground-middleground, and background distance zones, and the level of contrast likely would reduce the inventoried sensitivity level designations in the analysis area. Table E.7.3 shows the acreages and percentages of BLM sensitivity classes where viewers would have visibility toward the Project. Table E.7.4 summarizes BLM distance zones where viewers would have visibility toward the Project. The Project's viewshed is shown in Figure 3.7.1, BLM sensitivity levels are shown in Figure 3.7.3, and the distance zones are shown in Figure 3.7.4.

Table E.7.3. Sensitivity Classes in the Analysis Area and Viewshed

Area	High Acres (%)	Medium Acres (%)	Low Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	2,640,936.7 (47.8%)	0.0 (0.0%)	0.0 (0.0%)	2,883,854 (52.2%)	**5,524,791 (100%)**
In Project viewshed	1,977,415.4 (44.0%)	0.0 (0.0%)	0.0 (0.0%)	2,515,637 (56%)	**4,493,052 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have sensitivity classifications.

Table E.7.4. Distance Zones in the Analysis Area and Viewshed

Area	Foreground-Middleground Acres (%)	Background Acres (%)	Seldom-Seen Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	2,189,130.0 (39.6%)	454,130.9 (8.2%)	0.0 (0.0%)	2,881,530.1 (52.2%)	**5,524,791 (100%)**
In Project viewshed	1,616,814.7 (36.0%)	362,132.6 (8.1%)	0.0 (0.0%)	2,514,104.7 (55.9%)	**4,493,052 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have distance zone classifications.

1.5 Bureau of Land Management Visual Resource Inventory Classes in the Project Viewshed

The BLM VRI classes indicate the overall value of landscape on BLM lands. Views to the action alternatives from more valued landscapes have greater potential for impacts than do views from less valued landscapes. Table E.7.5 shows the acreages and percentages of existing BLM VRI classes in the analysis area and the Project's viewshed. Construction, operations, and reclamation activities would result in overall landscape values that strongly contrast with existing conditions. The Project would result in strong contrasts to the landscape for viewers in the foreground, middleground, and background distance zones, and the level of impact would likely reduce the inventoried BLM VRI class designations in the analysis area. The VRI classes are shown in Figure 3.7.5, and the Project's viewshed is shown in Figure 3.7.1.

Table E.7.5. Visual Resource Inventory Classes in the Analysis Area and Viewshed

Area	Class I Acres (%)	Class II Acres (%)	Class III Acres (%)	Class IV Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	0.0 (0.0%)	214,276.6 (3.9%)	1,974,862.3 (35.7%)	451,806.8 (8.2%)	2,883,854.3 (52.2%)	**5,524,791 (100%)**
In Project viewshed	0.0 (0.0%)	184,689.1 (4.1%)	1,432,125.6 (31.9%)	360,600.7 (8.0%)	2,515,636.6 (56%)	**4,493,052 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have Visual Resource Inventory classifications.

1.6 Bureau of Land Management Visual Resources Management Classes Overlapped by the Project

Conformance with VRM management classes is based on the characteristics of project facilities that are physically located within the VRM classified lands. The Project facilities are physically located within VRM Class II and Class IV areas (Figure 3.7.6). As described in Table E.7.1, the objectives for VRM Class II and IV are as follows:

The VRM Class II objective provides for activities where

> *The objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.* (BLM 1986)

The VRM Class IV objective provides for activities where

> *The objective is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.* (BLM 1986)

Conformance with the VRM objectives is determined by comparison of the forms, lines, colors, and textures of view characteristics of the Project with forms, lines, colors, and textures of views of the existing characteristic landscape where they are physically located. Within these areas, the Project does not conform with VRM Class II objectives and does conform with VRM Class IV objectives.

The acreage of the respective VRM classes within the analysis area and the Project viewshed are shown in Table E.7.6. The acres of each VRM class that is within the Project viewshed provides a summary of the amount of those areas from which a viewer can see the Project facilities.

Table E.7.6. Visual Resources Management Classes in the Analysis Area and Viewshed

Area	Class I Acres (%)	Class II Acres (%)	Class III Acres (%)	Class IV Acres (%)	Unclassified, Not in NPR-A Acres (%)	Total Acres (%)
In analysis area	0.0 (0.0%)	828,266.7 (15.0%)	117,974.6 (2.1%)	1,601,227.9 (29.0%)	2,977,321.8 (53.9%)	**5,524,791 (100%)**
In Project viewshed	0.0 (0.0%)	758,379.8 (16.9%)	78,510.1 (1.7%)	1,048,949.8 (23.4%)	2,607,212.3 (58%)	**4,493,052 (100%)**

Note: NPR-A (National Petroleum Reserve in Alaska). Areas outside of NPR-A are not managed by the Bureau of Land Management and thus do not have Visual Resources Management classifications.

2.0 REFERENCES

BLM. 1986. *Blm Manual H-8410-1: Visual Resource Inventory*.

-----. 2012. *National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement*. Anchorage, AK.

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Willow Master Development Plan

Appendix E.7B
Visual Contrast Rating Worksheets

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Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch Please see Appendix N Map Figure N-1
2. Key Observation Point (KOP) Name Foreground-MiddlegroundViews		
3. VRM Class at Project Location Class IV	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds..	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING _SHORT TERM ✔ LONG TERM

1. DEGREE OF CONTRAST	FEATURES											
	LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
ELEMENTS	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
FORM		✔				✔			✔			
LINE		✔				✔			✔			
COLOR		✔				✔			✔			
TEXTURE			✔				✔			✔		

2. Does project design meet visual resource management objectives? ✔ Yes ___No (Explain on reverses side)

3. Additional mitigating measures recommended ✔ Yes ___No (Explain on reverses side)

Evaluator's Names: Merlyn Paulson
Date: 03/08/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Strong construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Strong contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities, equipment, and vehicles. These contrasts would conform with Visual Resource Management Class IV management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.

Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues for humans and fauna.

Strong contrasts would be reduced to moderate and then weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives

Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.

Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch Please see Appendix N Map Figure N-1
2. Key Observation Point (KOP) Name Background-Seldom Seen Views		
3. VRM Class at Project Location Class IV	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds.	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING _SHORT TERM ✔ LONG TERM

1\. DEGREE OF CONTRAST

	FEATURES												
	LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)				
ELEMENTS	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
FORM			✔				✔			✔		
LINE			✔				✔			✔		
COLOR			✔				✔			✔		
TEXTURE			✔				✔				✔	

2\. Does project design meet visual resource management objectives? ✔ Yes ___No
(Explain on reverses side)

3\. Additional mitigating measures recommended
✔ Yes ___No (Explain on reverses side)

Evaluator's Names: Merlyn Paulson
Date: 03/08/2019

(Continued on Page 2)

SECTION D. (Continued)

Comments from item 2.

Moderate to weak construction-related contrasts in the background and seldom seen areas (5-15 and greater miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Moderate contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities and vehicles. These contrasts would conform with Visual Resource Management Class III and IV management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.

Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues with humans and fauna.

Moderate contrasts would be reduced to weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives

Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.

Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Form 8400-4
(June 2018)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
VISUAL CONTRAST RATING WORKSHEET

Date: 03/08/2019
District Office: Arctic
Field Office:
Land Use Planning Area:

SECTION A. PROJECT INFORMATION

1. Project Name Willow	4. KOP Location (T.R.S) Varies	5. Location Sketch Please see Appendix N Map Figure N-1
2. Key Observation Point (KOP) Name Foreground-MiddlegroundViews		
3. VRM Class at Project Location Class II	(Lat. Long) Varies	

SECTION B. CHARACTERISTIC LANDSCAPE DESCRIPTION

	1. LAND/WATER	2. VEGETATION	3. STRUCTURES
FORM	Planar horizontal land, lakes and ponds.	Planar horizontal surface of grasses in summer turning to snow cover for 9-10 months..	None
LINE	Strongly horizontal land, lakes, and ponds.	Horizontal surface of grasses in summer turning to snow cover for 9-10 months.	None
COLOR	Very light to medium tan earth. Water reflecting colors of sky in summer turning to snow cover for 9-10 mo	Light to medium green turning to tan to brown grasses in summer and uniform snow cover for 9-10 months	None
TEX-TURE	Smooth land, lakes, and ponds	Smooth grasses and snow cover	None

SECTION C. PROPOSED ACTIVITY DESCRIPTION

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FORM	Flat, planar pads and roads	Geometric patterns of present and absent grasses.	Strongly planar vertical and horizontal drill and valve structures. Cylindrical tanks. Geometric roads, pads, vehicles.
LINE	Horizontal pads and curvilinear roads	Horizontal and angular lines at edges of geometric shapes.	Strongly vertical and horizontal lines. Vertical and horizontal lines at edges of geometric shapes
COLOR	Tans and greys	Greens, tans, and greys.	Light to dark orange structures and multicolored equipment. White, blue, and red facility, vehicle lighting, sky glow.
TEX-TURE	Smooth.	Smooth to coarse at a distance.	Moderate to coarse.

SECTION D. CONTRAST RATING ___SHORT TERM ✔ LONG TERM

1.

DEGREE OF CONTRAST		FEATURES											
		LAND/WATER BODY (1)				VEGETATION (2)				STRUCTURES (3)			
		STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE	STRONG	MODERATE	WEAK	NONE
ELEMENTS	FORM		✔				✔			✔			
	LINE		✔				✔			✔			
	COLOR		✔				✔			✔			
	TEXTURE			✔				✔			✔		

2. Does project design meet visual resource management objectives? ___Yes ✔ No
(Explain on reverses side)

3. Additional mitigating measures recommended
✔ Yes ___No (Explain on reverses side)

Evaluator's Names: Merlyn Paulson
Date: 03/08/2019

(Continued on Page 2)

Comments from item 2.

Strong construction-related contrasts in the foreground and middleground seen areas (0-5 miles) would occur for the 10-11-year time period specified (Chapter 2.4.6.10.2) for drilling and from the presence of drill rigs and construction equipment. Strong contrasts would be caused by the structural forms, lines, and colors and colors of lighting for facilities, equipment, and vehicles. These contrasts would not conform with Visual Resource Management Class II management objectives (see following table). These noticeable forms and lines are required for function and the highly contrasting colors are needed for safety in the region's extreme weather conditions. Thus, they would cause strong contrasts in the characteristic landscape and mitigations of color would not be feasible.
Dark Sky BMP Re: down-shielded lighting – This BMP would limit direct (line-of-sight) visibility of the standard Osha-mandated lighting at facilities. However, down-shielding in snow cover conditions is known to increase reflectiveness toward the sky and the resultant sky glow and light dome would cause problematic navigation issues for humans and fauna.
Strong contrasts would be reduced to moderate and then weak during the operations, maintenance, and reclamation phases of the project. These phases would be portrayed by pads, roads, pipelines, and vehicles, and, eventually, less-noticeable forms, lines, and colors in the landscape.

BLM Visual Resource Management Class Objectives
Class I Objective The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
Class II Objective The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic (design) elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
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Class IV Objective The objective Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.
Source: BLM 1986, 2008b.

Additional Mitigating Measures (See item 3)

Willow Master Development Plan

Appendix E.8
Water Resources Technical Appendix

August 2019

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List of Figures

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List of Acronyms

cfs	cubic feet per second
CPAI	ConocoPhillips Alaska, Inc.
HDD	horizontal directional drilling
MBI	Michael Baker International
mm	millimeters
NAVD88	North American Vertical Datum of 1988
NWS	National Weather Service
Project	Willow Master Development Plan Project
RM	River Mile
USGS	U.S. Geological Survey
VSM	vertical support member
WSE	water surface elevation

Glossary Terms

Discharge – The rate at which a given volume of water passes a given location within a specific period of time (e.g., cubic feet per second or gallons per minute).

Stage – The vertical height of the water above an established but usually arbitrary point. Sometimes zero stage corresponds to the riverbed but more often to just an arbitrary point.

Water surface elevation – The elevation of the water surface of a river, lake, or stream above an established reference or vertical datum.

1.0 WATER RESOURCES

1.1 General Flow Characteristics of Rivers and Streams in the Analysis Area

Freeze-up often begins with ice forming along the shoreline and ice pans floating down the river. As freeze-up continues the ice cover spreads across the stream and in shallow locations the entire water column freezes. Stream flow during the winter on the North Slope is generally so low that it is not measurable and is often nonexistent. In late May or early June there is a rapid rise in **discharge** resulting from snowmelt runoff, a period generally referred to as spring breakup. More than half the annual discharge for a stream can occur during spring breakup, a period of several days to a few weeks. Extremely large areas can be inundated in a matter of days as the result of rapid snowmelt combined with ice- and snow-blocked channels. Most streams continue to flow through the summer, but at substantially lower discharges. Rainstorms can increase streamflow temporarily, but they are seldom sufficient to produce a discharge comparable to that which occurs in the average spring breakup. Streamflow rapidly declines in most streams shortly after the onset of freeze-up, in September, and ceases in most streams by December.

1.1.1 Influence of Climate Change on Flow

Though climate change is occurring, it is unknown how it might impact flood-peak magnitude and frequency in the Arctic. The National Weather Service (NWS) evaluated the potential for statistically significant trends in the 1-day and 1-hour annual maximum daily precipitation data for Alaska (for stations that had at least 40 years of data), which are often used to predict flood-peak discharge (Perica, Kane et al. 2012). There was no trend in 1-hour annual maximum precipitation for the 12 stations with 40 years of record. Of the 154 stations with 40 years of 1-day annual maximum precipitation data, 85% had no statistically significant trends, 8% had a positive trend, and 7% had a negative trend. Spatial maps did not reveal any spatial cohesiveness in positive and negative trends.

U.S. Geological Survey (USGS) evaluated the flood-peak data set used to develop regression equations to predict flood-peak discharge throughout Alaska (Curran, Barth et al. 2016). Statistically significant trends were detected at 43 of the 387 stream gages evaluated. Of the 43 stream gages with significant trends, 22 had increasing trends and 21 had decreasing trends.

Although precipitation levels are projected to increase, the longer warmer summers may increase evapotranspiration. An increase in evapotranspiration may result in a net loss in surface water by the end of the summer season, which could affect the size, depth, and areal extent of thaw lakes. Increases in winter precipitation may have some effect on lake recharge and on peak snowmelt runoff in rivers and streams.

1.2 Hydrology of Rivers and Streams in the Willow Area

1.2.1 Fish Creek (Uvlutuuq and Iqalliqpik Channels)

Fish Creek (Uvlutuuq and Iqalliqpik) has its headwater in the Arctic Foothills and flows into Harrison Bay just east of the Colville River Delta. It has a drainage area of approximately 836 square miles, including its major tributaries: Judy (Kayyaaq) Creek, Judy (Iqalliqpik) Creek, and the Ublutuoch (Tiŋmiaqsiġvik) River (Figure 3.8.2). The Willow Master Development Plan Project (Project) would cross or come near to all of these tributaries, which are described below. The Uvlutuuq channel of Fish Creek is upstream of the confluence with Judy (Iqalliqpik) Creek, and the Iqalliqpik channel of Fish Creek is downstream of the confluence.

The Project would cross Fish (Uvlutuuq) Creek at approximately River Mile (RM) 55.5. At RM 55.5 the bankfull width is approximately 330 feet, the average bankfull depth is approximately 4.5 feet, and the depth to thalweg is approximately 6.4 feet (CPAI 2018b).

Spring breakup **stage** and discharge have been measured in Fish (Uvlutuuq) Creek for 17 years at RM 32.4 (Table E.8.1) (Aldrich 2018), about 22.8 river miles downstream from the proposed infrastructure.

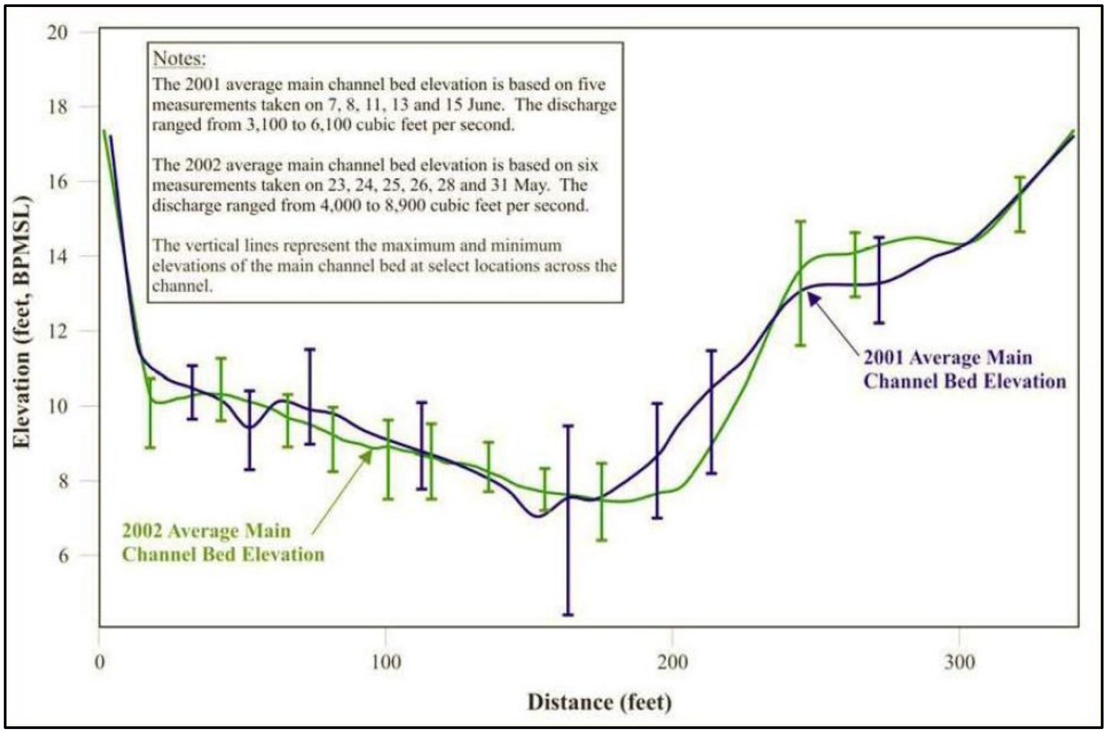
During that time, the date on which water began to flow was between May 12 and June 5, with a median date of May 27. The annual peak discharge occurred between May 23 and June 18, with a median date of June 9. In 6 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference between the peak stage and the stage at the peak discharge was 1.51 feet. The time from the beginning of flow to the peak discharge varied between 6 and 24 days, with a median time of 11 days. The annual peak discharge varied from 2,040 to 5,400 cubic feet per second (cfs), with a median of 3,370 cfs. Freeze-up data were collected in 14 of the 17 years. During that time, freeze-up occurred between October 4 and October 30, with a median date of October 17.

Table E.8.1. Summary of Annual Peak Stage and Annual Peak Discharge for Fish (Uvlutuuq) Creek at River Mile 32.4

Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/5	N/A	6/15	22.25	3640	6/15	22.25	3640	10
2002	5/17	N/A	5/27	22.42	3685	5/27	22.42	3685	10
2003	6/1	10/7 e	6/12	23.87	3470	6/12	23.87	3470	11
2004	6/2	10/30 e	6/9	23.48	4410	6/9	23.48	4410	7
2005	6/5	10/10 e	6/6	21.74	1040	6/1	21.44	2800	13
2006	5/27	10/16 e	6/12	21.72	3170	6/12	21.72	3170	16
2007	5/31	10/17 e	6/9	20.57	2200	6/9	20.57	2200	9
2008	5/23	10/4 e	6/6	20.12	2270	6/6	20.12	2270	14
2009	5/21	10/13	6/3	21.49	3240	6/3	21.49	3240	13
2010	6/1	10/8	6/9	23.50	3730	6/9	23.50	3730	8
2011	5/28	10/23	6/3	23.12	2120	6/8	21.61	2610	11
2012	5/25	10/20	6/6	22.25	2720	6/11	21.93	3510	17
2013	5/31	10/17	6/12	23.98	5400	6/12	23.98	5400	12
2014	5/15	10/17	5/20	22.35	2290	6/8	21.77	3370	24
2015	5/17	10/8	5/23	24.14	4830	5/23	24.14	4830	6
2016	5/12	10/21	5/27	20.10	1470	5/31	20.08	2040	19
2017	5/27	N/A	6/2	21.00	1510	6/7	20.96	2740	11

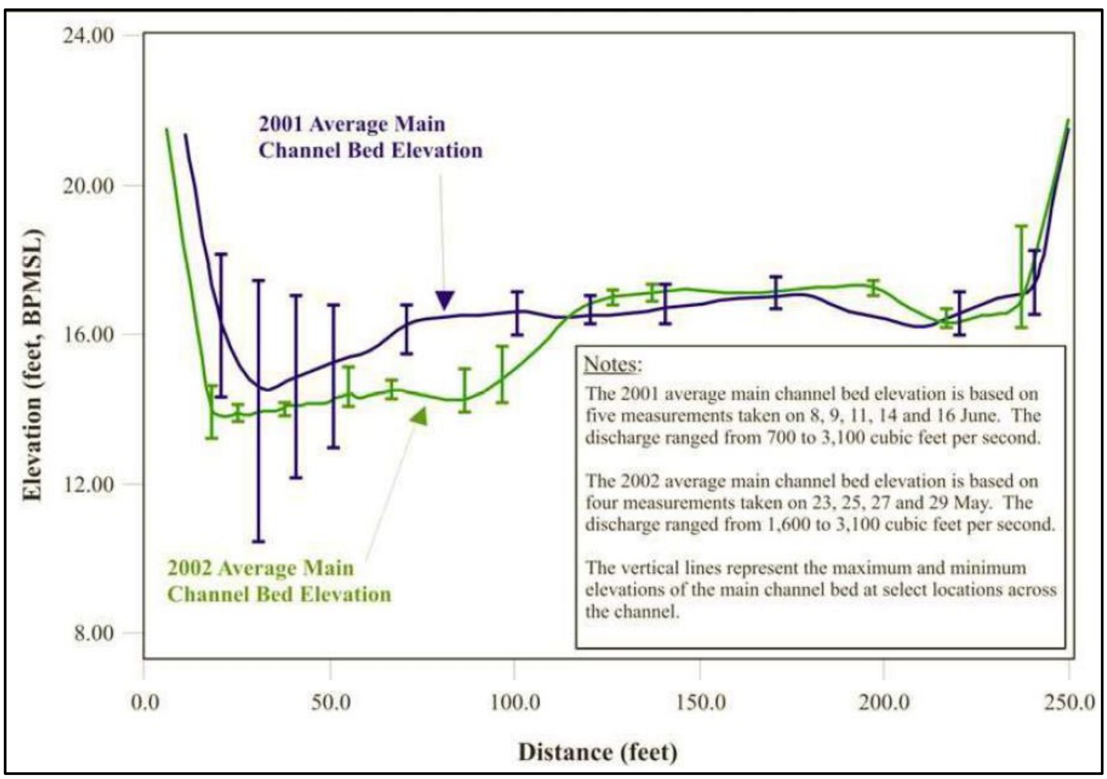
Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge); RM (river mile). Coordinates of site (NAD27): 70.2706, -151.8692.
Source: Aldrich 2018

Both the Iqalliqpik and Uvlutuuq channels of Fish Creek are relatively low gradient and highly sinuous. Undercut stream banks and bank sloughing are common along the outside of meander bends (URS Corporation 2003). The riverbed appears to be very mobile. The river banks and bed of Fish Creek (both Iqalliqpik and Uvlutuuq channels) are composed of a mixture of sand and silt, with a median riverbed grain size of 0.13 millimeters (mm) at RM 25.1 and 0.037 mm at RM 32.4 (URS Corporation 2001). During the 2001 spring breakup, the maximum observed change in riverbed elevation was 5 feet at River Mile (RM) 25.1 and 7 feet at RM 32.4 (URS Corporation 2001). During the 2002 spring breakup, the maximum observed change in riverbed elevation was 3 feet at RM 25.1 and 1 foot at RM 32.4 (URS Corporation 2003). Figures E.8.1 and E.8.2 present the average riverbed elevation in 2001 and 2002 at RM 25.1 and RM 32.4, respectively. Also shown is the extent of the deviations from average during those years.



Source: URS Corporation 2003

Figure E.8.1. Average Riverbed Elevation in Fish (Iqalliqpik) Creek at River Mile 25.1, 2001 and 2002



Source: URS Corporation 2003

Figure E.8.2. Average Riverbed Elevation in Fish (Uvlutuuq) Creek at River Mile 32.4, 2001 and 2002

On May 26, 2002, the discharge, suspended sediment load, and bedload were all measured at RM 25.1. The discharge was 8,900 cubic feet per second (cfs) (the same as the annual peak discharge recorded the day before), the bedload was 423 tons per day, the suspended sediment load was 8,400 tons per day, and the total sediment load was computed to be 8,800 tons per day (URS Corporation 2003). The concentration of the suspended sediment was 349 milligrams per liter. Approximately 6.1% of the bedload was composed of organic material (URS Corporation 2003). The median diameter of the mineral portion of the bedload was 0.12 mm, and the specific gravity of the mineral portion of the bedload was 2.640 (URS Corporation 2003).

The daily changes in the channel bed that were recorded during the 2001 and 2002 breakups suggest that the bed is easily eroded, moved, and shaped by the flow (URS Corporation 2003). The interaction of the water-sediment mixture and the sand bed can create different bed configurations, such as ripples, dunes, transition, and antidunes. The type of bed form present affects both the hydraulic roughness and the rate of sediment transport, which affects the water velocity, depth of scour, and **water surface elevation**. At RM 25.1, dunes are probably present at discharges of 3,100 to 4,800 cfs (URS Corporation 2003). At discharges between 6,100 and 8,900 cfs both dunes and antidunes are probably present (URS Corporation 2003). The antidunes are probably confined to the deepest and/or fastest portions of the channel (URS Corporation 2003). As the discharge increases beyond 6,100 cfs, the portion of the bed covered by antidunes is likely to increase (URS Corporation 2003). At RM 32.4, both ripples and dunes are probably present at discharges of 1,500 to 2,300 cfs (URS Corporation 2003). At discharges between 3,100 and 3,700 cfs dunes are probably the predominant bed form.

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during spring breakup using data collected in both 2001 and 2002. At RM 25.1, the channel hydraulic roughness on the day of the measurements was 0.021 in both 2001 and 2002 (URS Corporation 2003). At RM 32.4, the channel hydraulic roughness on the day of the measurements was 0.028 in 2001 and 0.030 in 2002 (URS Corporation 2003). At RM 43.3, the channel hydraulic roughness on the day of the measurements was 0.027 both in 2001 and 2002. Although the values probably change from day to day during breakup and from year to year, the computed values are within the range of values one would expect when dunes and antidunes are present on the riverbed (0.014–0.035). Computations of hydraulic roughness based on measured discharge and water surface slope, and normal depth computations, on 5 to 6 days during breakup in both 2001 and 2002 suggested a slightly bigger range in hydraulic roughness values but the values are still within the range one would expect when dunes and antidunes are present (URS Corporation 2003).

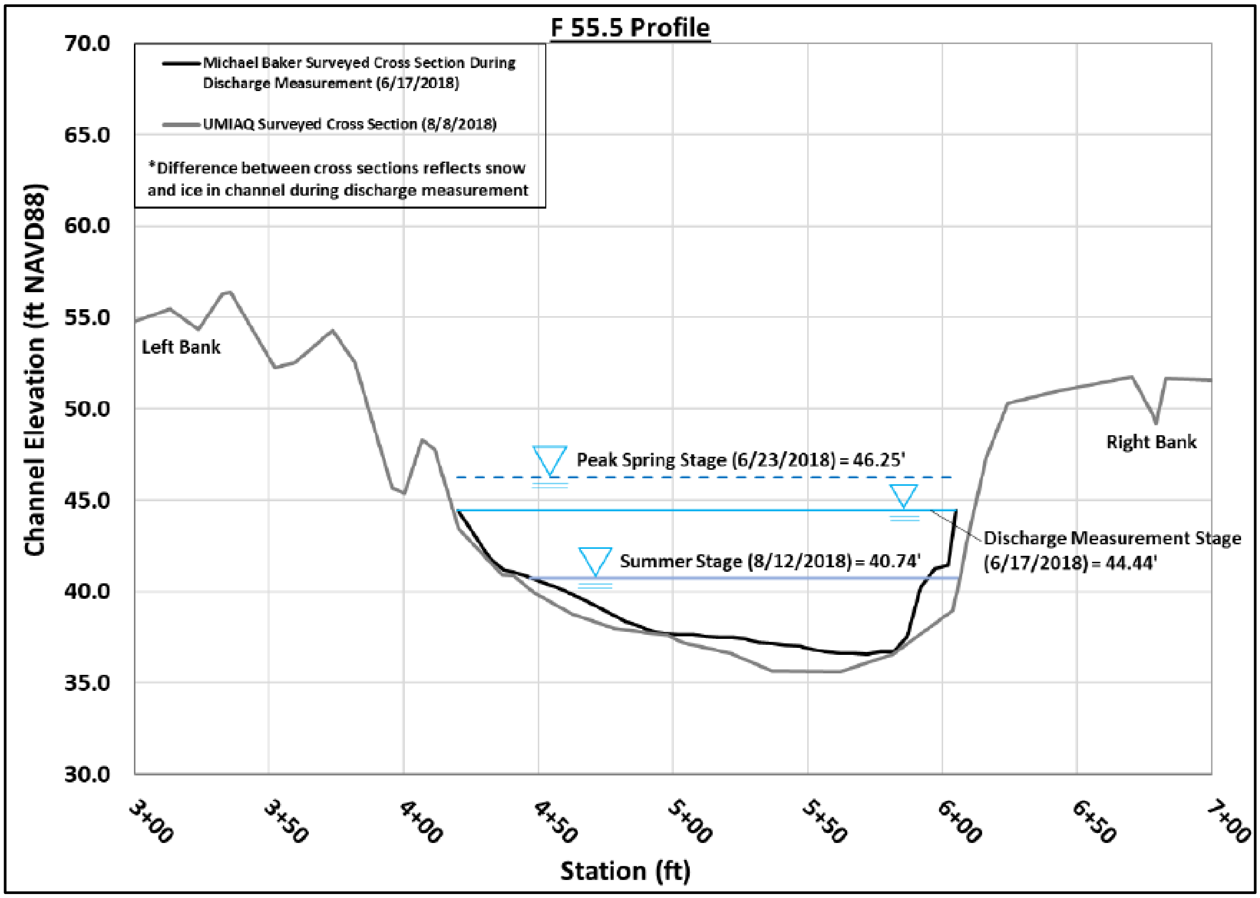
Seventeen years of summer flow data is available for Fish (Uvlutuuq) Creek at RM 32.4 (Aldrich 2018). A summary of the available mean monthly discharge data is provided in Table E.8.2.

Table E.8.2. Mean Monthly Discharge (cubic feet per second) in Fish (Uvlutuuq) Creek at River Mile 32.4

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	–	–	–	–	–	1,761	697	412	298	242	208	173
2002	137	104	70	35	808	1,118	526	252	259	230	199	168
2003	137	107	77	47	16	1,620	633	391	341	173	25	0
2004	0	0	0	0	0	2,311	732	331	298	196	38	0
2005	0	0	0	0	0	1,484	750	282	171	44	6	0.2
2006	0	0	0	0	47	1,643	555	298	210	132	40	2
2007	0	0	0	0	0	10,004	259	66	37	12	0.1	0
2008	0	0	0	0	112	911	224	113	73	17	0	0
2009	0	0	0	0	432	1,684	405	179	196	63	5	0
2010	0	0	0	0	0	1,719	532	321	191	59	3	0
2011	0	0	0	0	37	1,600	437	206	185	120	28	2
2012	0	0	0	0	15	1,748	459	240	256	185	25	0
2013	0	0	0	0	0.6	2,617	803	439	386	293	27	0
2014	0	0	0	0	753	2,014	877	353	282	190	31	0.7
2015	0	0	0	0	1424	1,637	402	203	165	62	19	0.6
2016	0	0	0	0	325	1,085	372	245	518	352	45	1
2017	0	0	0	0	91	1,555	486	619	846	806	262	14

Source: Aldrich 2018

In 2018, a monitoring site was established at RM 55.5 (Michael Baker Jr. Inc. 2018). Observations during the 2018 spring breakup indicated the peak stage (46.25 feet NAVD88) occurred 0.5 hour after the peak discharge (4,400 cfs; water surface elevation [WSE] 46.03 feet NAVD88) and at a time when the channel was not impacted by snow or ice within the channel at the monitoring site (Michael Baker Jr. Inc. 2018). This suggests that the peak stage was due to backwater, possibly due to an ice jam downstream. Prior to the peak discharge, water surface elevations at the monitoring site had been impacted by snow and ice in the channel and an ice jam (Michael Baker Jr. Inc. 2018). It was also noted that the riverbed was mobile during spring breakup (Michael Baker Jr. Inc. 2018). Figure E.8.3 presents a cross-section of the channel showing the discharge measurement. In general, the water surface elevation decreased throughout the summer, but increased in early September in response to a rain event (Michael Baker Jr. Inc. 2018). Maximum and minimum summer WSEs were 43.17 feet NAVD88 (fall rainfall peak) and 40.74 feet NAVD88.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.3. Cross-Section on Fish (Uvlutuuq) Creek at River Mile 55.5

Table E.8.3 presents flood-peak magnitude and frequency estimates for Fish (Uvlutuuq) Creek at RM 55.5 based on the Curran et al. (2003) USGS 2003 regression equations (Michael Baker Jr. Inc. 2018).

Table E.8.3. Flood Magnitude and Frequency in Fish (Uvlutuuq) Creek at River Mile 55.5

Percent Chance of Exceedance in Any Given Year (%)	Recurrence Interval (years)	Annual Peak Discharge (cfs)
50	2	10,400
20	5	15,200
10	10	18,200
4	25	21,800
2	50	24,400
1	100	26,900

Source: Michael Baker Jr. Inc. 2018

Spring breakup observations have also been made at the following sites.

- RM 0.7 in 2001 (URS Corporation 2001), 2002 (URS Corporation 2003), 2005 (Michael Baker International 2005), and 2006 (Michael Baker International 2007).
- RM 10.3 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007).
- RM 11.7 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003).
- RM 12.6 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003).
- RM 18.4 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003).
- RM 25.1 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007).
- RM 32.4 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007).
- RM 43.3 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003).

Hydraulic designs on Fish (Uvlutuuq) Creek should consider the flood-peak data that have been collected on Fish (Uvlutuuq) Creek at RM 32.4, the highly mobile bed, the impact of ice and snow on annual peak WSEs, and the riverbed forms and hydraulic roughness likely to be present at the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Fish (Uvlutuuq) Creek basin, the 17 years of data collected at RM 32.4 should be considered. Single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 32.4. A “best estimate” of the flood-peak magnitude and frequency at RM 32.4 could then be developed from a weighted average, based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis, and the Shell regression equations[1] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basins as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values will provide estimates with high WSEs and lower velocities. Lower hydraulic roughness values will provide estimates with lower WSEs and higher velocities. Both conditions are important when designing structures within the channel and floodplain.

1.2.1.1 Willow Creek 8

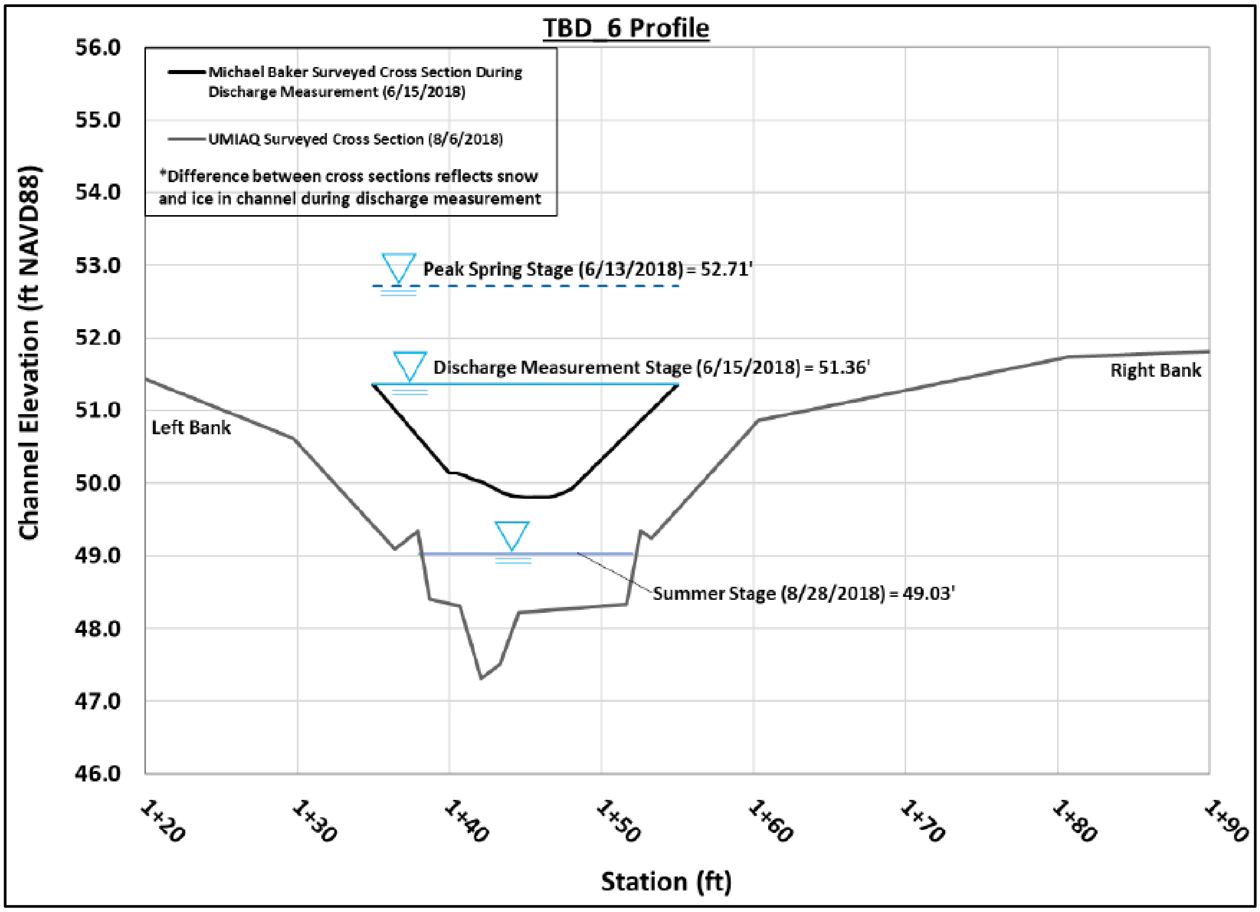
Willow Creek 8 is a tributary of Fish (Uvlutuuq) Creek. It has a meandering, incised channel with intermittent deep, beaded pools (Michael Baker Jr. Inc. 2018). The infield road for all action alternatives would cross Willow Creek 8 at the MBI TBD_6 and SW22 monitoring sites, about 1.7 and 3 RM upstream of the Fish (Uvlutuuq) Creek confluence, respectively (Michael Baker Jr. Inc. 2018). At the SW22 crossing, Willow Creek 8 has a poorly defined channel in a low-lying area of polygon troughs connecting Lake M0305 to an unnamed lake to the south (Michael Baker Jr. Inc. 2018). At TBD_6, the Willow Creek 8 channel is incised and well defined. At TBD_6, the bankfull width is approximately 32 feet and the average bankfull depth is approximately 4.8 feet (CPAI 2018b). Monitoring sites TBD_6 and SW22 were established in 2018.

Due to low relief and the wide area of possible flow paths, the SW22 gage was not placed in the main flow path and neither peak stage nor peak discharge information was collected during the 2018 spring breakup (Michael Baker Jr. Inc. 2018). At TBD_6 peak stage was 52.71 feet NAVD88 and occurred on June 13. At the time of the peak stage there was snow and ice in the channel and overbank flooding (Michael Baker Jr. Inc. 2018). It is likely that the peak stage occurred prior to the peak discharge (Michael Baker Jr. Inc. 2018). The date of and the magnitude of the peak discharge were not recorded.

Figure E.8.4 shows a cross-section of the channel at TBD_6 including a cross-section from a June 15, 2018, discharge measurement, and the 2018 spring peak stage. The difference in the cross-sections, and the difference between the June 13 and 15 WSEs, is an indication of the magnitude of the impact of snow and ice on the peak stage and during the likely time of the peak discharge.

In general, the stage at TBD_6 fell throughout the summer except for fluctuations due to summer precipitation events (Michael Baker Jr. Inc. 2018). At the end of the summer monitoring season, the stage increased due to a late summer precipitation event (Michael Baker Jr. Inc. 2018). However, the stage remained well below spring breakup peak stage throughout the summer (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at TBD_6 were 50.18 feet and 49.03 feet NAVD88 (Michael Baker Jr. Inc. 2018).

[1] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data were used to prepare the Shell regression equations than the USGS regression equations.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.4. Cross-Section of Willow Creek 8 at Monitoring Site TBD_6

1.2.1.2 Judy (Iqalliqpik) Creek

Judy (Iqalliqpik) Creek has its headwater in the Arctic Foothills and flows into Fish (Iqalliqpik) Creek at RM 26. Much of the Project infrastructure would be within the Judy (Iqalliqpik) Creek basin; Alternatives B (Proponent's Project) and D (Disconnected Access) would cross the main stem of Judy (Iqalliqpik) Creek at approximately RM 21.4 (Michael Baker Jr. Inc. 2018). At RM 21.4, the bankfull width is approximately 175 feet and the average bankfull depth is approximately 2.0 feet (CPAI 2018b). Several tributaries of Judy (Iqalliqpik) Creek are also crossed by the infrastructure: Judy (Kayyaaq) Creek, Willow Creek 1, Willow Creek 2, Willow Creek 3, Willow Creek 4, and Willow Creek 4A.

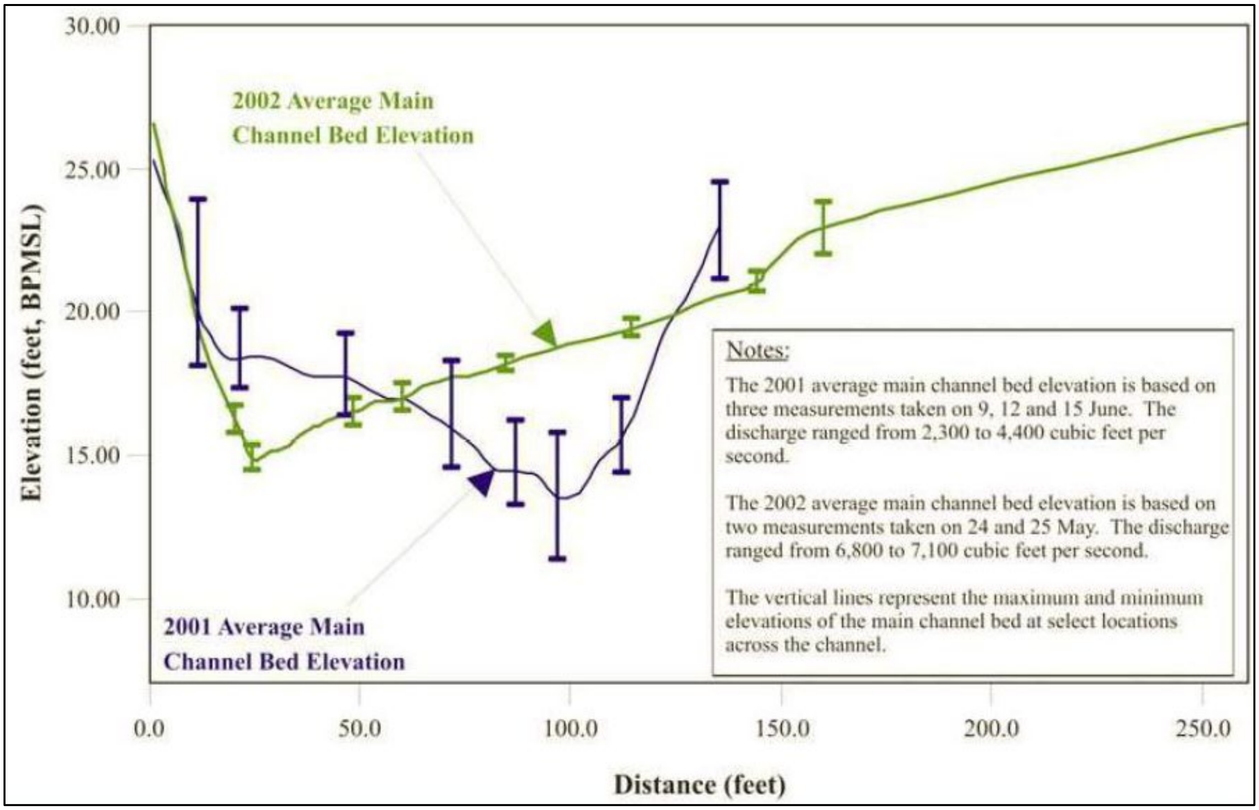
Spring breakup stage and discharge have been measured on the main stem of Judy (Iqalliqpik) Creek for 17 years at RM 7 (Aldrich 2018), about 13.3 river miles downstream from the proposed infrastructure (Table E.8.4). During that time, the date on which water began to flow was between May 11 and June 5, with a median date of May 26. The annual peak discharge occurred between May 18 and June 10, with a median date of June 5. In 6 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference was 2.39 feet. The time from the beginning of flow to the peak discharge varied between 1 and 12 days, with a median time of 8 days. The annual peak discharge varied from 2,250 to 9,210 cfs, with a median of 4,770 cfs. Freeze-up data were collected in 14 of the 17 years. During that time, freeze-up occurred between September 20 and October 11, with a median date of September 26.

Table E.8.4. Summary of Annual Peak Stage and Discharge for Judy (Iqalliqpik) Creek at River Mile 7

Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/5	N/A	6/10	27.11	N/A	6/10	27.11	5590	5
2002	5/18	N/A	5/25	26.81	N/A	5/25	26.81	7150	7
2003	5/31	9/25	6/6	28.00	N/A	6/6	25.61	4720	7
2004	5/18	9/26	5/26	28.55	N/A	6/5	26.62	4770	8
2005	6/2	9/26	6/6	27.47	N/A	6/10	25.99	4400	8
2006	5/26	10/5	5/30	26.00	N/A	6/7	24.97	3930	12
2007	5/26	9/23	6/5	25.40	N/A	6/5	25.40	4560	10
2008	5/22	9/29	5/29	24.93	N/A	5/29	24.93	3850	7
2009	5/18	9/23	5/27	25.16	N/A	5/28	24.78	2250	10
2010	6/2	9/26	6/8	27.95	N/A	6/8	27.95	9210	6
2011	5/30	10/1	5/31	30.05	N/A	5/31	29.66	5480	1
2012	5/26	10/9	6/5	26.86	N/A	6/5	26.86	6950	10
2013	5/31	9/26	6/9	26.86	N/A	6/9	26.86	6300	10
2014	5/14	10/10	5/18	30.07	N/A	5/18	30.07	5410	4
2015	5/18	9/20	5/22	29.21	N/A	5/22	29.21	5990	4
2016	5/11	10/11	5/22	26.21	N/A	5/22	26.21	4010	11
2017	5/26	N/A	6/3	25.85	N/A	6/3	25.85	4070	8

Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge); RM (river mile). Coordinates of site (NAD27): 70.2206, -151.8352).
Source: Aldrich 2018.

Judy (Iqalliqpik) Creek has a relatively low gradient and a highly sinuous channel. Undercut stream banks and bank sloughing are common along the outside of meander bends (URS Corporation 2003). The Judy (Iqalliqpik) Creek riverbed appears to be very mobile. The river banks and bed are composed of a mixture of sand and silt, with a median riverbed grain size of 0.17 mm at RM 7 (URS Corporation 2001). During the 2001 spring breakup, the maximum observed change in riverbed elevation at RM 7 was 5 feet (URS Corporation 2001). During the 2002 spring breakup the maximum observed change in riverbed elevation at RM 7 was 2 feet (URS Corporation 2003). Figure E.8.5 presents the average riverbed elevation in 2001 and 2002 at RM 7, and the deviations from average during those years.



Source: URS Corporation 2003

Figure E.8.5. Average Riverbed Elevation for Judy (Iqalliqpik) Creek at River Mile 7, 2001 and 2002

The daily changes in the channel bed that were recorded during the 2001 and 2002 breakups suggest that the bed is easily eroded, moved, and shaped by the flow (URS Corporation 2003). At RM 7, dunes are probably present at discharges on the order of 2,300 cfs (URS Corporation 2003). At discharges between 3,200 and 7,000 cfs both dunes and antidunes are probably present (URS Corporation 2003). The antidunes are probably confined to the deepest and/or fastest portions of the channel (URS Corporation 2003). At discharges above 7,000 cfs it is likely that antidunes cover the bed (URS Corporation 2003).

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during spring breakup using data collected in both 2001 and 2002. At RM 7 the channel hydraulic roughness on the day of the measurements was 0.014 in 2001 and 0.024 in 2002 (URS Corporation 2003). At RM 13.8 the channel hydraulic roughness on the day of the measurements was 0.020 in 2001 and 0.024 in 2002 (URS Corporation 2003). Although the values probably change from day to day during breakup and from year to year, the computed values are within the range of values one would expect when dunes and antidunes are present on the riverbed (0.014–0.035). Computations of hydraulic roughness based on measured discharge and water surface slope, and normal depth computations, at RM 7 on several different days suggest that in 2001 the hydraulic roughness during ice- and snow-impacted conditions varied from 0.022 to 0.028 (URS Corporation 2003). Similar computations during open water conditions in 2001 and 2002 suggest that the hydraulic roughness varies from 0.13 to 0.022.

Seventeen years of summer flow data is available for Judy (Iqalliqpik) Creek at RM 7 (Aldrich 2018). A summary of the available mean monthly discharge data is provided in Table E.8.5.

Table E.8.5. Mean Monthly Discharge (cubic feet per second) in Judy (Iqalliqpik) Creek at River Mile 7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	–	–	–	–	–	1,448	175	175	176	129	78	26
2002	0	0	0	0	1273	492	285	166	155	110	66	22
2003	0	0	0	0	1	1,306	307	171	214	60	0.9	0
2004	0	0	0	0	493	1,786	263	155	221	51	3	0
2005	0	0	0	0	0	1,717	271	72	63	13	0	0
2006	0	0	0	0	93	1,559	164	133	85	38	4	0
2007	0	0	0	0	1	879	65	21	14	2	0	0
2008	0	0	0	0	334	775	91	65	42	4	0	0
2009	0	0	0	0	513	904	103	90	166	38	3	0
2010	0	0	0	0	0	1,718	149	220	113	18	1	0
2011	0	0	0	0	250	1,473	167	81	151	65	3	0
2012	0	0	0	0	64	1,785	132	82	161	86	3	0
2013	0	0	0	0	6	2,537	264	170	186	93	8	0
2014	0	0	0	0	1044	1,469	310	134	166	85	8	0
2015	0	0	0	0	1268	650	128	89	110	12	0	0
2016	0	0	0	0	977.4	570.3	106	139	358	308	41	0
2017	0	0	0	0	165	1,557	144	512	753	600	73	3

Source: Aldrich 2018

At RM 13.8, spring breakup peak WSEs have been measured periodically since 2001 (Table E.8.6).

Table E.8.6. Historical Peak Stage in Judy (Iqalliqpik) Creek at River Mile 13.8

Year	Peak Stage (feet BPMSL)	Date
2018	37.09	6/6
2017	34.68	6/4
2006	35.56	5/30
2005	37.25	6/4
2004	–	–
2003	36.58	6/6
2002	35.86	5/25
2001	39.66	6/7

Note: BPMSL (British Petroleum Mean Sea Level). Table adapted from Table 4.3 (Michael Baker Jr. Inc. 2018).

Observations made during the 2018 spring breakup at RM 13.8 indicated the peak stage (37.09 feet NAVD88) occurred prior to the peak discharge (4,100 cfs; WSE 36.37 feet NAVD88). On the day of the peak discharge some intermittent ice floes were observed and considerable snow was present along each bank, but no bottom-fast ice was observed (Michael Baker Jr. Inc. 2018). It was also noted that the riverbed was mobile on both the day of the peak discharge and 10 days after the peak discharge, and that on the later date a moving bed velocity averaging 0.7 feet per second was observed (Michael Baker Jr. Inc. 2018).

At RM 21.4 spring breakup monitoring was conducted in 2017 and 2018 (CPAI 2018a; Michael Baker Jr. Inc. 2018). In 2017 the peak stage was recorded as 90.2 feet (arbitrary datum; [CPAI 2018a]), and in 2018 the peak stage was recorded as 51.24 feet NAVD88 (Michael Baker Jr. Inc. 2018). In 2018 it was noted that the channel bed was highly mobile during spring breakup (Michael Baker Jr. Inc. 2018). Summer stage was measured in 2018 and indicated that the stage fluctuated with precipitation, but water levels remained below peak spring breakup stage (Michael Baker Jr. Inc. 2018). The stage increased at the end of the summer monitoring period due to a late summer precipitation event. Maximum and minimum summer WSEs were 47.49 feet NAVD88 (fall rainfall peak) and 44.78 feet NAVD88.

Table E.8.7 presents flood-peak magnitude and frequency estimates for Judy (Iqalliqpik) Creek at RM 13.8 based on the Curran et al. (2003) USGS 2003 regression equations (Michael Baker Jr. Inc. 2018).

Table E.8.7. Flood Magnitude and Frequency in Judy (Iqalliqpik) Creek at River Mile 13.8.

Percent Chance of Exceedance in Any Given Year (%)	Recurrence Interval (years)	Annual Peak Discharge (cubic feet per second)
50	2	7,400
20	5	10,900
10	10	13,100
4	25	15,800
2	50	17,700
1	100	19,500

Source: Michael Baker Jr. Inc. 2018

Spring breakup observations have also been made at the following sites.

- RM 16.5 in 2017 (CPAI 2018a)
- RM 31.0 in 2001 (URS Corporation 2001)

Hydraulic designs on Judy (Iqalliqpik) Creek should consider the flood-peak data that have been collected on Judy (Iqalliqpik) Creek at RM 7, the highly mobile bed, the impact of ice and snow on annual peak water surface elevations, and the riverbed forms and hydraulic roughness likely to be present at the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Judy (Iqalliqpik) Creek basin, the 17 years of data collected at RM 7 should be considered. A single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 7. A best estimate of the flood-peak magnitude and frequency at RM 7 could then be developed from a weighted average, based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis, and the Shell regression equations[2] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basins as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values would provide estimates with higher water surface elevations and lower velocities. Lower hydraulic roughness values would provide estimates with lower water surface elevations and higher velocities. Both conditions are important when designing structures within the channel and floodplain.

1.2.1.2.1 Judy (Kayyaaq) Creek

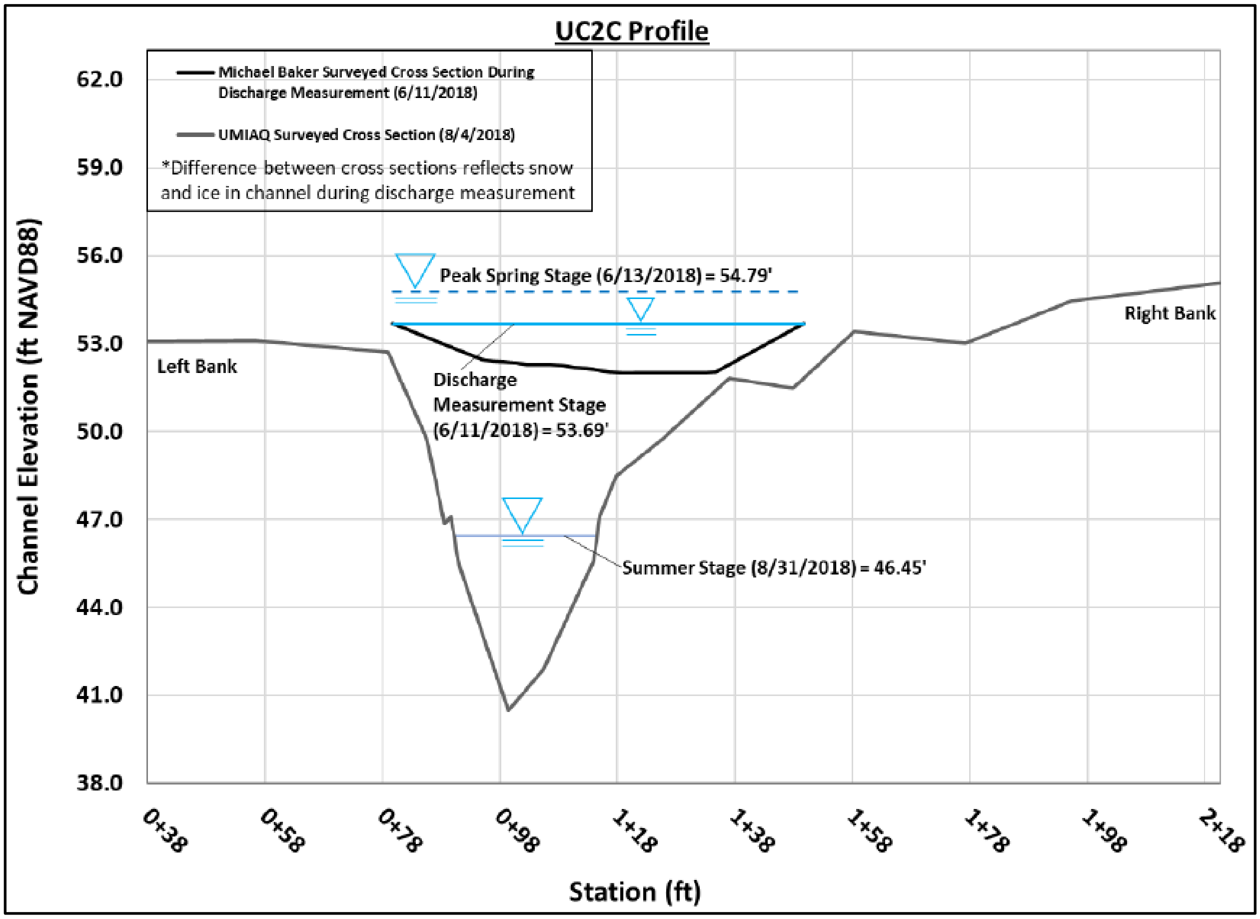
Judy (Kayyaaq) Creek is a tributary to Judy (Iqalliqpik) Creek. It has a highly sinuous and incised channel: over 8 feet from top of bank to streambed, and typically about 30 feet wide (Michael Baker Jr. Inc. 2018). The UC2A, UC2B and UC2C gaging stations were established at approximately RM 8.4, 10.2 and 13.0, respectively (Michael Baker Jr. Inc. 2017). The UC2C gaging station is located where the infield road (for all action alternatives) would cross Judy (Kayyaaq) Creek (Michael Baker Jr. Inc. 2017), about 13 miles upstream from the confluence with Judy (Iqalliqpik) Creek. At RM 13.0 (UC2C gage) the bankfull width is approximately 20 feet and the average bankfull depth is approximately 5.5 feet (CPAI 2018b). Spring breakup and summer stage have been monitored in both 2017 and 2018.

In both 2017 and 2018 the channel was full of wind-blown snow prior to the start of breakup (Michael Baker Jr. Inc. 2017, 2018). In 2017 it was reported that water began flowing on top of the drifted snow at all of the monitoring stations, and then cut a channel down through the wind-blown snow (Michael Baker Jr. Inc. 2017). It was also stated that in 2017 the peak stage at all of the monitoring stations was elevated above bankfull by snow and ice in the channel, and that the peak stage probably did not occur at the same time as the peak discharge (Michael Baker Jr. Inc. 2017). At UC2C the peak stage in 2017 was 99.88 feet (arbitrary datum) and occurred on May 30 (Michael Baker Jr. Inc. 2017). In 2018, the peak stage at UC2C was 54.78 feet NAVD88 and occurred on June 13 (Michael Baker Jr. Inc. 2018). In 2018, the peak stage was believed to have occurred at the same time as the peak discharge (Michael Baker Jr. Inc. 2018). At

[2] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data was used to prepare the Shell regression equations than the USGS regression equations.

the time of the peak stage, it was reported that there was "overbank flooding and minimal impedance from snow" (Michael Baker Jr. Inc. 2018). However, since an observer could probably not have seen through 13-plus feet of water (Figure E.8.6), it seems unknown whether or not the peak stage and/or the stage at the peak discharge were impacted by snow and ice in the bottom of the channel. No estimate for the 2018 peak discharge was provided (Michael Baker Jr. Inc. 2018). Bankfull conditions with some overbank flooding in low-lying areas persisted through at least June 18.

Figure E.8.6 presents a surveyed cross-section at UC2C and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSE's on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.6. Cross-Section of Judy (Kayyaaq) Creek at Gaging Station UC2C

In both 2017 and 2018 summer stage fluctuated with precipitation but water levels remained below spring breakup peak stage. The maximum and minimum stages recorded at UC2C during the summer of 2017 were 93.1 feet and 90.85 feet (both based on an arbitrary datum). The maximum and minimum stages recorded at UC2C during the summer of 2018 were 47.81 feet and 46.45 feet NAVD88. In both years the stage increased in the beginning of September as the result of precipitation events.

1.2.1.2.2 Willow Creek 1

Willow Creek 1 is a tributary of Judy (Iqalliqpik) Creek. Alternatives B (Proponent's Proposal) and C (Disconnected Infield Roads) would cross Willow Creek 1 between Lake R0060 and Lake M0016, which is also where the W1S monitoring site is located in a poorly defined low-lying area (Michael Baker Jr. Inc. 2018).

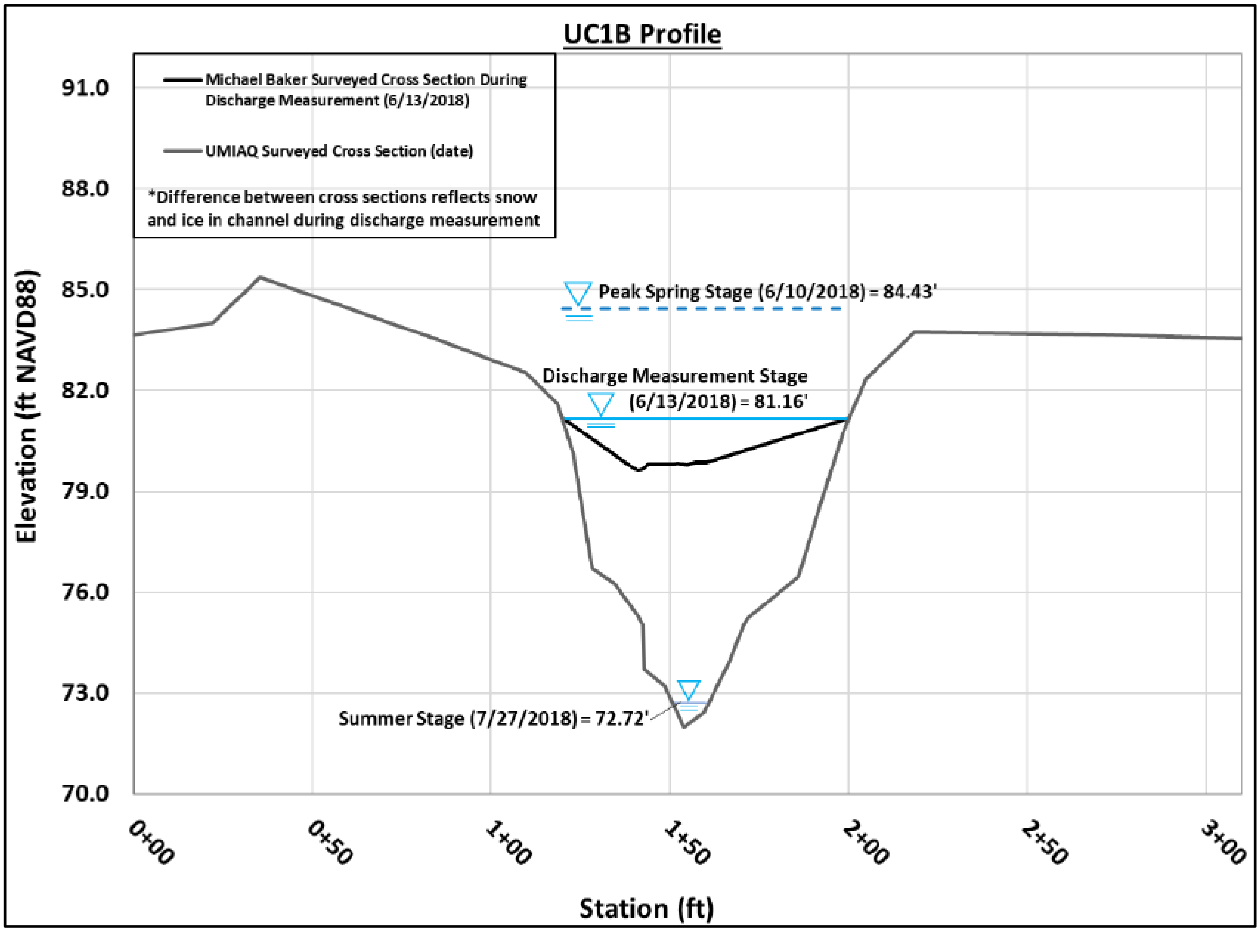
The 2018 spring breakup peak stage at W1S was 79.16 feet NAVD88 and occurred on June 6 (Michael Baker Jr. Inc. 2018). Throughout the entire breakup monitoring period no distinguishable channel or discernible flow was identified near W1S, and the peak stage was probably the result of ponded local melt (Michael Baker Jr. Inc. 2018). During the summer, small stage fluctuations associated with summer precipitation were recorded, but water levels remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at W1S were 78.59 feet NAVD88 and 78.39 feet NAVD88 (Michael Baker Jr. Inc. 2018). During the summer, no defined channel or flow was observed, only standing water (Michael Baker Jr. Inc. 2018).

1.2.1.2.3 Willow Creek 2

Willow Creek 2 is a tributary of Judy (Iqalliqpik) Creek. Willow Creek 2 has a highly sinuous, deeply incised, beaded channel (Michael Baker Jr. Inc. 2018). It is over 10 feet from the top of bank to the streambed and has a typical channel width of 20 feet (Michael Baker Jr. Inc. 2017). Alternatives B (Proponent's Proposal) and C (Disconnected Infield Roads) would cross Willow Creek 2 at RM 4.5, and the UC1B monitoring site is located on Willow Creek 2 at the proposed crossing (Michael Baker Jr. Inc. 2018). At RM 4.5, the bankfull width is approximately 4.5 ft and the average bankfull depth is approximately 2.5 feet (CPAI 2018b). Spring breakup and summer stage were monitored at UC1B in both 2017 and 2018.

In both 2017 and 2018, the channel was full of wind-blown snow prior to the start of breakup (Michael Baker Jr. Inc. 2017, 2018). In both years it was reported that water began flowing on top of the drifted snow, and then cut a channel down through the wind-blown snow (Michael Baker Jr. Inc. 2017, 2018). In both years peak stage was reportedly affected by snow and ice in the channel and peak stage did not coincide with the peak discharge (Michael Baker Jr. Inc. 2017, 2018). In 2017 the peak stage at UC1B occurred on May 30 at 96.87 feet (arbitrary datum) (Michael Baker Jr. Inc. 2017). In 2018 the peak stage at UC1B occurred on June 10 at 84.42 feet NAVD88 (Michael Baker Jr. Inc. 2018). A spring peak discharge was not recorded in either year.

Figure E.8.7 presents a surveyed cross-section at UC1B and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSE's on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.7. Cross-Section of Willow Creek 2 at Monitoring Site UC1B

In both 2017 and 2018 summer stage fluctuated with precipitation but water levels remained below spring breakup peak stage. The maximum and minimum stages recorded at UC1B during the summer of 2017 were 84.63 feet and 83.01 feet (both based on an arbitrary datum) (Michael Baker Jr. Inc. 2017). The maximum and minimum stages recorded at UC1B during the summer of 2018 were 74.43 feet and 72.72 feet NAVD88 (Michael Baker Jr. Inc. 2018).

1.2.1.2.4 Willow Creek 3

Willow Creek 3 is a tributary of Judy (Iqalliqpik) Creek. All action alternatives would cross Willow Creek 3 between Lake M0015 and Lake R0055, which is also where the W3S monitoring site is located in a poorly defined low-lying area (Michael Baker Jr. Inc. 2018). At W3S, the bankfull width is approximately 18 feet and the average bankfull depth is approximately 2.0 feet (CPAI 2018b).

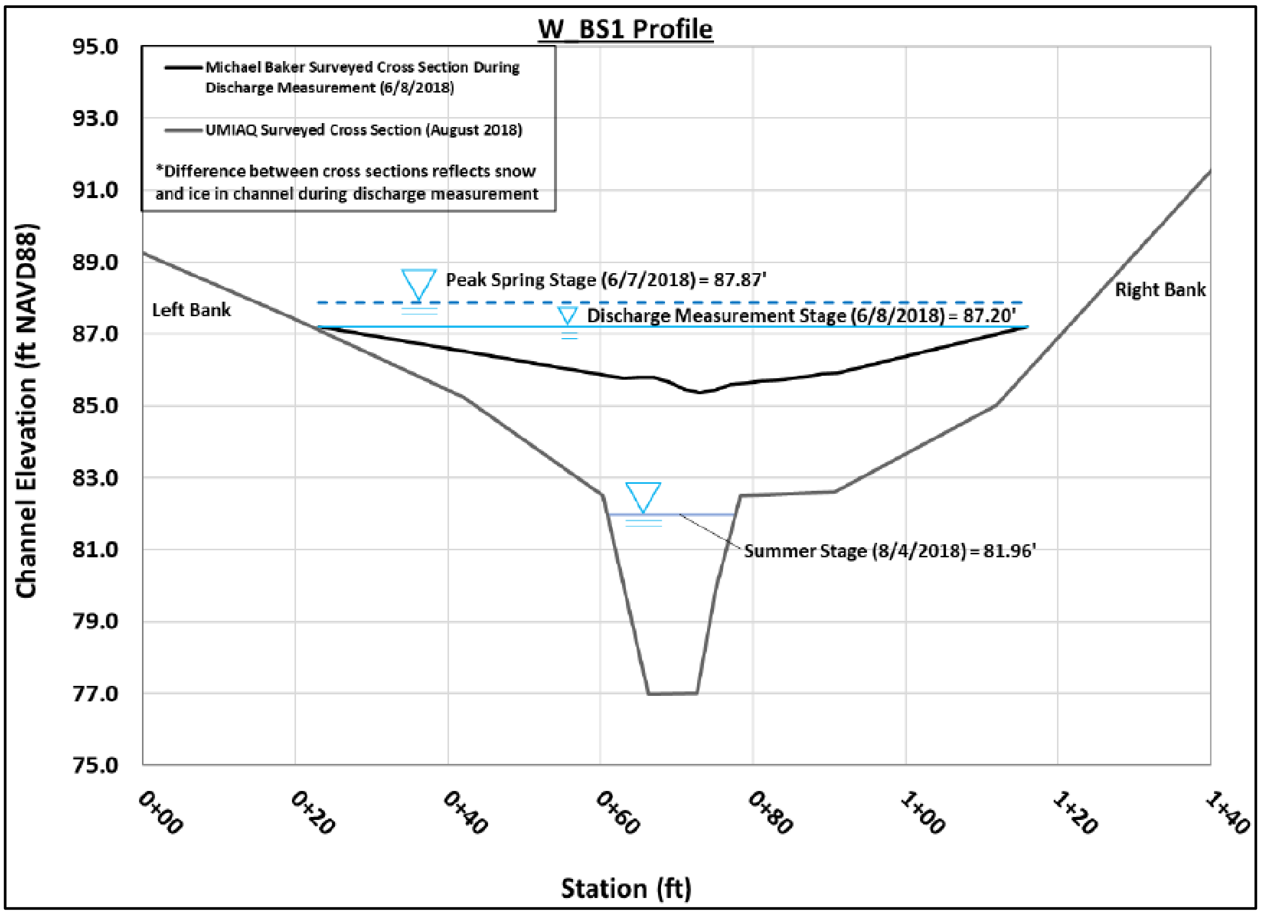
The 2018 spring breakup peak stage at W3S was 84.13 feet NAVD88 and occurred on June 4 (Michael Baker Jr. Inc. 2018). Peak stage was affected by ice and snow, but may have been the result of pooled local melt rather than flowing water(Michael Baker Jr. Inc. 2018). Eight days later (stage about 83.65 feet NAVD88), areas inundated by snowmelt and low-velocity flow were observed (Michael Baker Jr. Inc. 2018). During the summer, small stage fluctuations associated with summer precipitation were recorded, but water levels remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at W3S were 83.40 feet and 82.86 feet NAVD88 (Michael Baker Jr. Inc. 2018). Low-velocity flow through a poorly defined ephemeral channel was observed on July 9 (Michael Baker Jr. Inc. 2018).

1.2.1.2.5 Willow Creek 4

Willow Creek 4 is a tributary of Judy (Iqalliqpik) Creek. It has an incised channel with intermittent deep, beaded pools (Michael Baker Jr. Inc. 2018). The infield road for all action alternatives would cross Willow Creek 4 at RM 9, which is also the location of the W_BS1 monitoring site. At RM 9, the bankfull width is approximately 26 feet and the average bankfull depth is approximately 2.7 feet (CPAI 2018b). The W4 monitoring site is located at RM 5.2, adjacent to the BT3/Willow processing facility pad.

The 2018 spring breakup peak stage at W_BS1 was 87.87 feet NAVD88 and occurred on June 7 (Michael Baker Jr. Inc. 2018). The 2018 spring breakup peak stage at W4 was 96.38 feet (arbitrary datum) and also occurred on June 7 (Michael Baker Jr. Inc. 2018). Both peaks occurred after a short rapid rise in water surface elevation of 1.5 to 2 feet, and snow and ice within the channel affected the peak WSE at both sites. The timing of and the magnitude of the peak discharge were not recorded.

Figure E.8.8 presents a surveyed cross-section at W_BS1 and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSE's on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.8. Cross-Section of Willow Creek 4 at Monitoring Site W_BS1

During the summer the stage fluctuated with summer precipitation at both monitoring sites, but the water levels remained well below spring breakup peak stage (Michael Baker Jr. Inc. 2018). The stage at the end of the summer monitoring season increased due late summer precipitation. The maximum and minimum summer stages at W4 were 87.96 feet (arbitrary datum) and 85.11 feet (arbitrary datum) (Michael Baker

Jr. Inc. 2018). The maximum and minimum summer stages at W_BS1 were 83.79 feet and 81.96 feet NAVD88 (Michael Baker Jr. Inc. 2018).

1.2.1.2.6 Willow Creek 4A

Willow Creek 4A is a tributary of Willow Creek 4. The infield road for all action alternatives would cross Willow Creek 4A at Michael Baker International (MBI) Monitoring Site W_S1, established in 2018. The channel near W_S1 is beaded and has defined banks. It has a bankfull width of approximately 24 feet and an average bankfull depth of approximately 4.5 feet (CPAI 2018b).

The 2018 spring breakup peak stage at W_S1 was 101.93 feet NAVD88 and occurred on June 8 (Michael Baker Jr. Inc. 2018). It was affected by snow and ice in the channel (Michael Baker Jr. Inc. 2018). At the time of the peak stage, the meltwater was confined by saturated snow and the stage rose 1.5 feet in about 3 hours (Michael Baker Jr. Inc. 2018). The timing of and the magnitude of the peak discharge were not recorded.

In general, the stage fell throughout the summer except for fluctuations due to summer precipitation events (Michael Baker Jr. Inc. 2018). At the end of the summer monitoring season the stage increased due to a late summer precipitation event (Michael Baker Jr. Inc. 2018). However, the stage remained well below spring breakup peak stage throughout the summer (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at W_S1 were 98.67 feet and 98.22 feet NAVD88 (Michael Baker Jr. Inc. 2018).

1.2.1.3 Ublutuoch (Tiŋmiaqsiġvik) River

Ublutuoch (Tiŋmiaqsiġvik) River has its entire drainage basin on the Arctic Coastal Plain and flows into Fish (Iqalliqpik) Creek at RM 10. It has a drainage area of approximately 248 square miles, of which approximately 15% is covered by lakes (URS Corporation 2003). Two gravel mine site options are located in the Ublutuoch (Tiŋmiaqsiġvik) River drainage basin, one on each side of the Ublutuoch (Tiŋmiaqsiġvik) River. The downstream boundary of the gravel mine site study area would cross the Ublutuoch (Tiŋmiaqsiġvik) River at approximately RM 13.9.

Spring breakup stage and discharge have been measured on the main stem of the Ublutuoch (Tiŋmiaqsiġvik) River for 17 years at RM 13.7, about 0.2 river mile downstream from the downstream boundary of the gravel mine site study area (Table E.8.8). During that time, the date on which water began to flow was between May 17 and June 8, with a median date of May 30. The annual peak discharge occurred between May 19 and June 9, with a median date of June 5. In 9 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference was 1.82 feet in 2005. The time from the beginning of flow to the peak discharge varied between 1 and 7 days, with a median time of 3 days. The annual peak discharge varied from 55 to 3,200 cfs, with a median of 1,700 cfs. Freeze-up data were collected in 7 of the 17 years. During that time, freeze-up occurred between September 26 and October 21, with a median date of October 8.

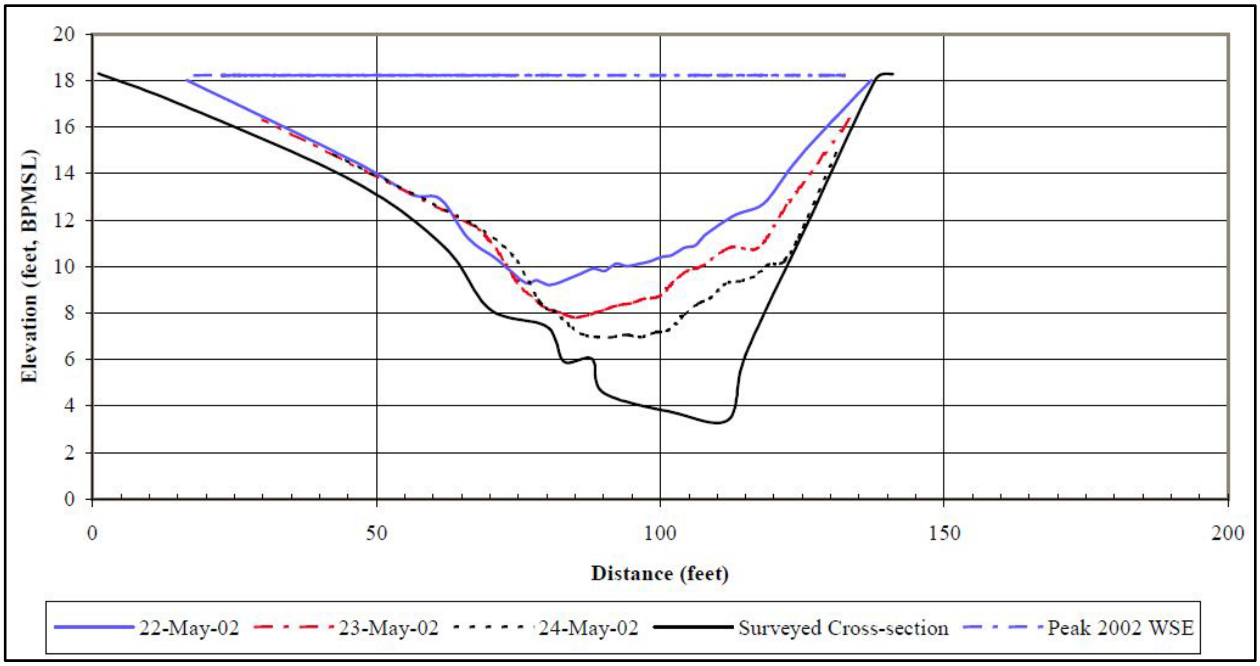
Table E.8.8. Summary of Annual Peak Stage and Discharge for Ublutuoch (Tiŋmiaqsiġvik) River at River Mile 13.7

Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/8	N/A	6/9	18.09	N/A	6/9	18.09	2200	1
2002	5/19 e	N/A	5/22	18.22	N/A	5/22	18.22	2000	3
2003	6/5	N/A	6/6	19.30	N/A	6/7	18.34	1600	2
2004	6/1	N/A	6/5	19.55	N/A	6/5	19.55	2400	4
2005	6/5	N/A	6/6	19.23	N/A	6/9	17.41	1520	4
2006	6/1 e	N/A	6/4	16.67	N/A	6/6	15.04	1250	5
2007	6/3	N/A	6/5	17.35	N/A	6/5	16.84	1520	2
2008	5/27	N/A	5/29	17.42	N/A	5/29	16.85	955	2
2009	5/25	10/8	5/28	18.90	N/A	5/28	18.34	1700	3
2010	6/5	9/27	6/7	19.68	N/A	6/7	19.68	3200	2
2011	5/30	N/A	6/1	19.17	N/A	6/3	17.91	1960	4
2012	5/30	10/11	6/5	18.33	N/A	6/5	18.33	2130	6
2013	6/2	10/4	6/5	19.29	N/A	6/9	18.47	2440	7
2014	5/17	10/11	5/19	18.61	N/A	5/19	18.61	1270	2
2015	5/20	9/26	5/22	19.91	N/A	5/23	19.26	2440	3
2016	5/22	10/21	5/24	17.76	N/A	5/24	17.76	1150	2
2017	5/28	N/A	5/31	16.69	N/A	5/31	16.69	1380	3

Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge); RM (river mile). Coordinates of site (NAD83): 70.24316, -151.29693
Source: Aldrich 2018

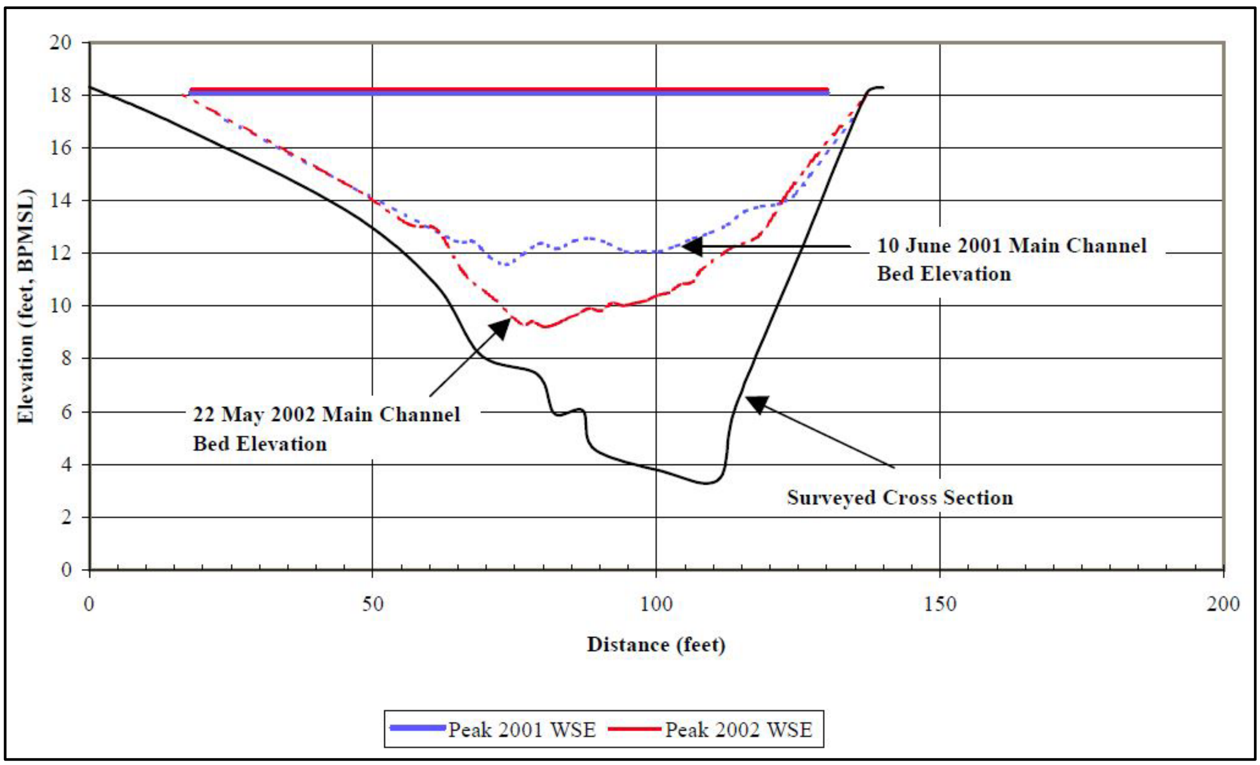
The Ublutuoch (Tiŋmiaqsiġvik) River has a relatively low gradient and highly sinuous channel. In the vicinity of RM 13.7 the channel is incised within relatively steep upper banks that are vegetated with dense brush (URS Corporation 2003). The lower portion of the channel consists of a relatively flat bench located approximately 10 to 15 feet below the top of the upper banks (URS Corporation 2003). A 2- to 3-foot-deep by 15- to 20-foot-wide low-water channel is located in the bottom of the otherwise vegetated channel (URS Corporation 2003). The riverbed is composed of sand and gravel, with a median diameter of 7.0 mm (URS Corporation 2003).

At the time of the 2001 and 2002 spring-peak water surface elevation and discharge, the water was flowing on snow within the channel. A comparison of riverbed elevation on various dates during the 2002 breakup at RM 13.7 is shown in Figure E.8.9, and 2001 and 2002 riverbed elevations at the time of the peak discharge are presented in Figure E.8.10.



Source: URS Corporation 2003

Figure E.8.9. Effect of Snow and Ice in 2002 on Channel Cross-Section at River Mile 13.7



Source: URS Corporation 2003

Figure E.8.10. Comparison of 2001 and 2002 Cross-Sections at Peak Discharge at River Mile 13.7

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during the 2002 spring breakup. At RM 8 and RM 13.7 the channel hydraulic roughness on the day of the measurements, when ice and snow were impacting the hydraulic conditions, was 0.012 and 0.021, respectively (URS Corporation 2003). Computations of hydraulic roughness based on measured discharge and water surface slope, and normal depth computations, at RM 13.7 each of 3 days in both 2001 and 2002 during ice and snow impacted conditions varied from 0.019 to 0.025, with a median of 0.023 (URS Corporation 2001, 2003).

Seventeen years of summer flow data is available for the Ublutuoch (Tiŋmiaqsiġvik) River at RM 13.7 (Aldrich 2018). A summary of the available mean monthly discharge data is provided in Table E.8.9.

Table E.8.9. Mean Monthly Discharge (cubic feet per second) in Ublutuoch (Tiŋmiaqsiġvik) River at River Mile 13.7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	0	0	0	0	0	435	47	45	38	27	16	5
2002	0	0	0	0	377	133	80	24	24	17	10	3
2003	0	0	0	0	0	389	112	57	52	6	0.5	0
2004	0	0	0	0	0	827	69	21	32	6	0.3	0
2005	0	0	0	0	0	467	78	13	7	2	0	0
2006	0	0	0	0	0	434	36	25	16	9	1	0
2007	0	0	0	0	0	283	18	2	0.5	0	0	0
2008	0	0	0	0	101	223	15	7	3	0.6	0	0
2009	0	0	0	0	241	456	27	12	31	15	4	0.6
2010	0	0	0	0	0	596	54	54	25	7	0.5	0
2011	0	0	0	0	11	628	33	10	12	7	0.8	0
2012	0	0	0	0	0.2	535	37	10	12	9	5	0.3
2013	0	0	0	0	0	857	72	26	30	8	2	0.1
2014	0	0	0	0	359	441	84	25	38	38	6	0.6
2015	0	0	0	0	438	208	18	14	16	2	0.2	0
2016	0	0	0	0	184	181	24	22	91	87	10	3
2017	0	0	0	0	92	367	18	78	200	150	23	0.1

Source: Aldrich 2018

At RM 14.5, (MBI Monitoring Site UB14.5) and RM 15.5 (MBI Monitoring Site UB15.5), spring breakup stage and extent of flooding was monitored in 2018 (Michael Baker Jr. Inc. 2018). RM 14.5 is just downstream of the mouth of Bill's Creek and RM 15.5 is just upstream. MBI (2018) also monitored stage and extent of flooding on Bill's Creek, monitoring site BC1. All of these sites are within the mine site study area.

At UB14.5, the channel is incised and deep, and fills with wind-blown snow during the winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage was 98.97 feet (arbitrary datum) and occurred on June 9. Pictures of the monitoring site on the day of the peak stage suggest that the peak stage was affected by snow and ice.

At UB15.5, the channel is incised and deep, and fills with wind-blown snow during the winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage was 92.78 feet (arbitrary datum) and occurred on June 8. Pictures of the monitoring site on the day of the peak stage suggest that the peak stage was affected by snow and ice.

Bill's Creek is a beaded channel consisting of large beads connected by deeply incised, narrow grass-lined channels with its headwaters in an area of small lakes (Michael Baker Jr. Inc. 2018). Wind-blown snow fills much of the drainage during the winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage at BC1 was 93.05 feet (arbitrary datum) and occurred on June 11. Based on the description of the conditions at the time of the peak stage (Michael Baker Jr. Inc. 2018) the peak stage was affected by snow and ice in the channel. Summer stage fluctuated with precipitation events, but remained below the peak breakup stage (Michael Baker Jr. Inc. 2018). The stage increased at the end of the summer monitoring period as a result of late summer precipitation (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages were 88.67 feet and 87.01 feet (arbitrary datum) (Michael Baker Jr. Inc. 2018).

Spring breakup observations have also been made at the following sites.

- RM 6.8 in 2003, 2004, 2005, 2006, 2009, 2010, 2011, and 2013 (CPAI 2018a)
- RM 8.0 in 2002 (URS Corporation 2003)
- RM 13.5 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)

Hydraulic designs on the Ublutuoch (Tiŋmiaqsiġvik) River should consider the flood-peak data that have been collected at RM 13.7, the impact of snow and ice at the time of the annual peak discharge, the impact of snow and ice on the annual peak water surface elevation, and the hydraulic roughness likely to be present at the time of the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Ublutuoch (Tiŋmiaqsiġvik) River basin, the 17 years of data collected at RM 13.7 should be considered. A single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 13.7. A best estimate of the flood-peak magnitude and frequency at RM 13.7 could then be developed from a weighted average, based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis, and the Shell regression equations[3] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basins as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values will provide estimates with higher WSEs and lower velocities. Lower hydraulic roughness values will provide estimates with lower WSEs and higher velocities. Both conditions are important when designing structures within the channel and floodplain. Additionally, snow blockage at the time of the peak discharge seems to be an annual occurrence and should be considered to estimating design water surface elevations.

1.2.2 Kalikpik River

The Kalikpik River originates in a complex network of lakes, approximately 15 miles south of Teshsepuk Lake, and flows into Harrison Bay northwest of Fish (Iqalliqpik) Creek (Michael Baker Jr. Inc. 2018). The river has a relatively low gradient, a highly sinuous channel, and the channel bed and banks consist predominantly of silt and sand (Michael Baker Jr. Inc. 2018). The most downstream end of the proposed infrastructure comes close to the Kalikpik River about 17.5 river miles upstream from the coast (RM 17.5).

In 2018, stage was monitored during spring breakup at Kal 1 (Michael Baker Jr. Inc. 2018), about 21.8 river miles upstream from the coast. The channel was full of windblown snow prior to the start of breakup (Michael Baker Jr. Inc. 2018). The peak stage occurred on June 11 at an elevation of 50.30 feet NAVD88, and was affected by snow and ice conditions (Michael Baker Jr. Inc. 2018). Snow remained along the banks and large ice floes were present in the channel for a couple of days following the peak stage (Michael Baker Jr. Inc. 2018). A second, smaller rise in stage was observed on June 16 and may have been coincident with the peak discharge (Michael Baker Jr. Inc. 2018). A discharge of 320 cfs was measured at a stage of 48.18 feet NAVD88 on June 16 at 4:00 PM. The stage was just below bankfull (Michael Baker Jr. Inc. 2018). No ice or snow was observed in the channel, but saturated snow remained along the south bank just above the water surface (Michael Baker Jr. Inc. 2018).

MBI (2018) continued to monitor stage during the summer. The stage fluctuated throughout the summer as a result of precipitation events, but remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). As a result of a late summer precipitation event, the stage increased to slightly higher than the stage during the discharge measurement near the end of the summer monitoring period (Michael Baker Jr. Inc. 2018).

[3] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data was used to prepare the Shell regression equations than the USGS regression equations.

At Kal 1, the bankfull width is approximately 140 feet, the average bankfull depth is approximately 3 feet, and the thalweg depth is approximately 8 feet (CPAI 2018b).

1.3 Environmental Consequences

1.3.1 Comparison of Action Alternatives and Options

Table E.8.10 details Project components that may affect water resources by alternative.

Table E.8.10. Comparison of Project Components That May Affect Water Resources

Impact	Alternative B: Proponent's Proposed Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Bridges (number)	7	6	6	NA	NA
Piles below OHW (number)	56	36	52	9	9
Culverts batteries (number)	11	10	8	NA	NA
Cross-drainage culverts (number)	202	194	149	NA	NA
VSMs below OHW (number)	14	32	14	NA	NA
Water withdrawal (millions of gallons, freshwater)	1,874.0	2,047.2	2,433.8	521.2	1,004.9
Miles of freshwater ice road	372.0	471.0	694.5	109.9	227.9
Acres of freshwater ice roads and ice pads	2,872.3	3,400.3	4,451.2	1,355.3	2,753.2
Acres of gravel fill	442.7	487.8	410.7	12.8	13.0
Acres of waterbodies in the dust shadow	96.8	81.6	80.2	NA	NA
Miles of diesel pipeline[a]	34.0	80.5	72.8	NA	NA

Note: NA (not applicable); OHW (ordinary high water)
[a] The Project would include other petroleum product pipelines (e.g., infield multiphase pipelines, sales oil pipeline), there is only a nominal difference in the overall lengths of these pipelines.

1.3.2 In-Water Structures

1.3.2.1 Bridge Crossings

The potential impacts to streams crossed by bridges during the life of the structure include:

- Increased backwater on the upstream side of the bridge
- Increased riverbed erosion within the bridge opening
- Increased riverbed and bank erosion downstream from the bridge
- Increased sediment deposition downstream from the bridge
- Increased sediment transport within and downstream from the bridge
- A change in channel morphology downstream from the bridge

The impact of a bridge on the stream being crossed is directly related to the criteria used to design the bridge and the extent to which the bridge is constructed according to the design. Some of the most important factors related to the hydraulic design of bridges on the North Slope include 1) the frequency of the design event in relation to the anticipated life of the structure, 2) the reliability of the computed magnitude and frequency of the design event, 3) the impact of snow and ice (including ice floes) at the time of the design event and during events with a smaller discharge than the design event, and 4) the reliability of the hydraulic computations used to estimate WSE and velocity, riverbed scour, and bank erosion. With regard to the frequency of the design event, the probability that the design event will not be exceeded during the life of the structure should be considered.

All bridges would be designed to maintain bottom chord clearance of 4 feet above the 100-year base flood elevation, and at least 3 feet above the highest documented flood elevation. Table E.8.11 presents the relationship between the average return period of the design event and the probability that the design event will not be exceeded during various lengths of time. Note that the probability that the design event will not be exceeded decreases as the life of the structure increases. Based on the life of past structures on the North Slope, it seems very likely that the life of the structures could be greater than 40 or 50 years. A culvert or bridge based on a 100-year flood design, that is likely to be in place for 50 years before removal or replacement, would have a 61% chance that the design flood would not be exceeded one or more times during the life of the structure (i.e., 39% chance that design flood would be exceeded). As shown, though it is more likely that the design life will not be exceeded during the life of the Project, there is still a 39% chance it could be. This section describes the potential effects of bridges.

Table E.8.11. Theoretical Probability That Design Event Will Not Be Exceeded in Specified Number of Years

Design Event (average return period in years)	10 years	20 years	30 years	40 year	50 years	60 years	70 years
25	66%	44%	29%	20%	13%	8%	6%
50	82%	67%	55%	45%	36%	30%	24%
100	**90%**	**82%**	**74%**	**67%**	**61%**	**55%**	**49%**
200	95%	90%	86%	82%	78%	74%	70%
500	98%	96%	94%	92%	90%	89%	87%

Note: **Bold** denotes the design life of bridges for the Project. The difference between the theoretical probability and the actual probability is the accuracy of the design events predicted probability of occurrence. For instance, if the design discharge is supposed to be a 100-year event, but actually has an average return period of 90 years, the theoretical probability that the design event will not be exceeded will be higher than what is experienced.

During floods in which the cross-sectional area of the flow is restricted by the bridge, water would back up behind the bridge. The difference between the unrestricted WSE and the restricted WSE on the upstream side of the bridge is called backwater. The magnitude of the backwater would depend upon the amount of constriction presented by the bridge or road embankments and would usually become larger with larger flood events. The maximum increase in WSE generally occurs at a location upstream from the bridge, about equal in distance to about one-half the total length of the embankment obstructing the flow of water. The upstream extent of the backwater is a function of both the magnitude of the constriction and the slope of the stream. The duration of the backwater would be somewhat less than the duration of the flood. Backwater is generally a concern if it causes a structure (such as an upstream pipeline) or another resource to be damaged by the inundation created as a result of the backwater.

The more a bridge restricts the flow (i.e., the greater the backwater), the higher the velocity through the bridge. At a particular discharge, if the velocity through the bridge exceeds the velocity that would have occurred prior to construction of the bridge, and the bed material is mobile at that velocity, it is likely that the depth of scour would be greater than would have occurred prior to bridge construction. Similarly, if the velocity downstream from the bridge is greater than the velocity that would have occurred prior to bridge construction, it is possible that bank erosion would be more severe than would have occurred. With increased erosion comes increased sediment transport and increased sediment deposition. An increase in erosion and deposition can lead to a change in channel morphology. If the bridge abutments or pier piles are undermined by scour, the bridge may collapse. Scour is historically one of the most common causes of bridge failure in North America (Cook 2014). However, scour is not a problem if it is correctly addressed during the design of the bridge.

1.3.2.2 Culverts

The potential impacts to streams crossed by culverts during the life of the structure include

- Increased backwater on the upstream side of the culvert
- Increased riverbed and bank erosion downstream from the culvert
- Increased sediment deposition downstream from the culvert
- Increased sediment transport downstream from the culvert
- A change in channel morphology downstream from the culvert

The impact of the culvert on the stream being crossed is directly related to the criteria used to design the culvert and the extent to which the culvert is constructed according to the design. The size, layout, and quantity of Project culverts would be based on site-specific conditions in order to pass the 50-year flood event with a headwater elevation not exceeding the top of the culvert (headwater to diameter ratio of 1 or less). Some of the most important factors related to the hydraulic design of culverts on the North Slope include 1) the frequency of the design event in relation to the anticipated life of the structure, 2) the reliability of the computed magnitude and frequency of the design event, 3) the impact of snow and ice (including ice floes) at the time of the design event and during events with a smaller discharge than the design event, 4) the reliability of the hydraulic computations used to estimate water surface elevation and velocity, riverbed scour, and bank erosion, and 5) the reliability of the topographic and flow information used to located the culvert. With regard to the frequency of the design event, see the discussion in Section 2.5.3.2.1, *Bridges*. A culvert based on a 50-year flood design, that is likely to be in place for 50 years before removal or replacement, would have a 36% chance that the design flood would not be exceeded one or more times during the life of the structure (i.e., 64% chance that design flood would be exceeded).

During floods in which the cross-sectional area of the flow is restricted by the culvert, water would back up behind the culvert. The magnitude of the backwater would depend upon the amount of constriction presented by the culvert. See discussion in Section 2.5.3.2.1, *Bridges,* for additional information.

The more the culvert restricts streamflow (i.e., the greater the backwater), the higher the velocity through the culvert. The higher the velocity through the culvert, the more likely it is that riverbed erosion (scour) and bank erosion would occur at the culvert outlet and downstream from the culvert. With increased erosion comes increased sediment transport and increased sediment deposition. An increase in erosion and deposition can lead to a change in channel morphology.

1.3.3 Pipelines

All of the pipeline waterbody crossings would be aboveground on vertical support members (VSMs) except for the Colville River crossing, which would be installed 85 feet belowground using horizontal directional drilling (HDD). Approximately 14 VSMs would be below ordinary high water.

1.3.3.1 Aboveground Crossings

As water passes around VSMs, at an aboveground crossing, there is the potential for an increase in velocity and scour. This may result in erosion at the VSM and sediment deposition downstream from the VSM. If ice floes or debris build up on a VSM, the scour at the VSM could be greater than anticipated and could compromise the integrity of the VSM and thus the pipeline.

If water, floating ice, or debris comes in contact with the aboveground pipeline, the pipeline could be ruptured. It is unknown to what flood event or ice condition the pipeline crossings would be designed.

Where an aboveground pipeline crossing is immediately upstream from a road crossing (either a bridge or a culvert), backwater from the road during the pipeline design event should be considered when setting the bottom of pipe elevation. Additionally, if the road is designed for a smaller flood than the pipeline, the changes in hydraulic conditions at the pipeline as a result of the road wash-out should be considered (i.e., changes in location of the concentrated flow and the impact on erosion at the VSM).

Where an aboveground pipeline crossing is immediately downstream from a road crossing (either a bridge or a culvert), the impact of the road on where water will be flowing and the velocity of the water at the pipeline VSM should be considered. Additionally, if the road is designed for a smaller flood than the pipeline, the changes in hydraulic conditions at the pipeline as a result of the road wash-out should be considered (i.e., changes in the location of the concentrated flow and the impact on erosion at the VSM).

1.3.3.2 Belowground Crossings

Design of the HDD crossing should consider the likely scour depth during all floods up to and including the design flood and the likely channel migration over the life of the crossing. It is unknown to what flood event the HDD crossing would be designed.

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Willow Master Development Plan

Appendix E.9
Vegetation and Wetlands Technical Appendix

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List of Acronyms

ACP	Arctic Coastal Plain
Willow area	Willow Master Development Plan area

Glossary Terms

Emergent – Of or denoting a plant which is taller than the surrounding vegetation.

Lacustrine – Produced or originating from or within a lake.

Palustrine – Produced or originating from or within a marsh.

Unconsolidated – Sediment that is loosely arranged or unstratified, or whose particles are not cemented together.

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1.0 VEGETATION AND WETLANDS

1.1 Affected Environment

Table E.9.1 details the wetland types in the Willow Master Development Plan area (Willow area; field-verified area) and the analysis area. Wetland types in the Willow area are not unique and occur in throughout the analysis area and the Arctic Coastal Plain (ACP). The table also shows the Cowardin code for each wetland type; Cowardin (1979) is a national classification system based on wetland characteristics. Draft EIS Figure 3.9.3 shows land cover classes in the analysis area (using data from the North Slope Science Initiative).

Table E.9.1. Vegetation by Wetland Type in the Analysis Area

Wetland Type	Cowardin Code[a]	Acres of Wetland Type the Analysis Area[b]	Acres of Wetland Type in Field-Verified Portion of Analysis Area[c]
Lacustrine Permanently Flooded Limnetic **Unconsolidated** Bottom Lake	L1UBH	511,145.7	117.4
Lacustrine Permanently Flooded Nonpersistent **Emergent** Marsh	L2EM2H	4,004.6	1.9
Marine Subtidal Unconsolidated Bottom Waters[c]	M1UBL	35,749.1	31.1
Palustrine Seasonally Saturated Persistent Emergent/Broad-Leaved Deciduous Shrub Meadow	PEM1/SS1B	528,450.7	2,699.8
Palustrine Continuously Saturated Persistent Emergent/Broad-Leaved Deciduous Shrub Meadow[d]	PEM1/SS1D	2,291.5	2,291.4
Palustrine Seasonally Flooded-Saturated Persistent Emergent/Broad-Leaved Deciduous Shrub Meadow	PEM1/SS1E	226,216.4	53.2
Palustrine Semipermanently Flooded Persistent Emergent/Broad-Leaved Deciduous Shrub Meadow	PEM1/SS1F	35,029.7	783.8
Palustrine Semipermanently Flooded Persistent Emergent Meadow	PEM1F	143,183.8	1,798.1
Palustrine Permanently Flooded Persistent Emergent Marsh[d]	PEM1H	233.6	233.6
Palustrine Permanently Flooded Nonpersistent Emergent Marsh	PEM2H	1,967.2	19.5
Palustrine Seasonally Saturated Broad-Leaved Deciduous Shrub/Unconsolidated Shore[d]	PSS1/USB	12.5	12.5
Palustrine Seasonally Saturated Broad-Leaved Deciduous Shrub Scrub	PSS1B	724.5	270.9
Palustrine Seasonally Flooded Broad-Leaved Deciduous Shrub Scrub	PSS1C	59.1	50.9
Palustrine Continuously Saturated Broad-Leaved Deciduous Shrub Scrub[d]	PSS1D	108.5	108.5
Palustrine Seasonally Saturated Broad-Leaved Evergreen Shrub Scrub[d]	PSS3B	97.9	97.9
Palustrine Permanently Flooded Unconsolidated Bottom Pond	PUBH	37,672.9	204.0
Riverine Permanently Flooded Tidal Stream[d]	R1UBV	11.3	11.3
Riverine Permanently Flooded Tidal Unconsolidated Shore[d]	R1USQ	10.5	10.5
Riverine Permanently Flooded Lower Perennial Stream	R2UBH	12,762.8	16.7
Riverine Seasonally Flooded Unconsolidated Shore	R2USC	9,898.9	11.5
Upland	U	7,915.0	119.5
Upland (fill)[d]	Us	13.2	13.2
Other Wetland Type	NA	2,023,637.94	0
Total	**NA**	**3,581,197.3**	**8,957.2**

Note: NA (not applicable). Bold terms (excluding "total") are defined in the glossary.
[a] Cowardin 1979, codes defined therein
[b] Wells et al. 2018 and USFWS 2016
[c] Wells et al. 2018
[d] Wetland type uses a higher resolution classification than USFWS (2016) and would only be documented through field verification. The lack of this wetland type in the rest of the analysis area is due to mapping methods and the fact that USFWS (2016) covers a broad area that did not receive the same level of field verification as the Willow area.

1.2 Comparison of Alternatives: Wetlands and Vegetation

Tables E.9.2 and E.9.3 detail the acres of direct fill in wetlands by action alternative. Table E.9.4. summarizes direct wetland loss by watershed and action alternative. Table E.9.5 summarizes direct habitat alteration at the mine site by wetland type. Table E.9.6 summarizes vegetation damage from ice infrastructure by action alternative. Table E.9.7 summarizes acres of indirect dust shadow on wetlands and vegetation. Tables E.9.8 and E.9.9 summarize indirect effects (dust shadow and vegetation damage) by watershed and action alternative or module delivery option.

Table E.9.2. Acres of Fill by Wetland Type

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access Road
L1UBH	0.0	0.3	0.0
L2EM2H	0.0	0.0	0.0
PEM1/SS1B	150.6	145.1	136.5
PEM1/SS1D	139.1	173.8	133.3
PEM1/SS1E	1.0	1.2	0.8
PEM1/SS1F	27.0	33.8	20.4
PEM1F	81.9	92.2	76.7
PEM1H	7.4	12.9	6.8
PEM2H	0.6	1.1	0.0
PSS1/USB	0.8	0.8	0.8
PSS1B	7.5	11.0	7.9
PSS1C	1.4	1.2	1.4
PSS1D	7.9	2.5	8.6
PSS3B	4.7	2.9	4.7
PUBH	6.0	3.8	6.0
R1UBV	0.0	0.0	0.0
R1USQ	0.0	0.0	0.0
R2UBH	0.6	0.4	0.6
R2USC	0.3	0.1	0.3
U	5.8	4.5	5.8
Us	0.0	0.0	0.0
Total	**442.6**	**487.6**	**410.6**
Total in Wetlands[a]	**429.9**	**478.6**	**397.9**
Total in Freshwater WOUS	**6.9**	**4.6**	**6.9**
Total in Uplands	**5.8**	**4.5**	**5.8**

Note: Cowardin codes defined in Table E.9.1. Numbers may differ slightly with other reported values in the EIS due to rounding. WOUS (Waters of the U.S.).
[a] Fill not in wetlands would be in uplands or freshwater WOUS (lakes or rivers).

Table E.9.3. Acres of Temporary Fill from Multi-Season Ice Pads by Wetland Type

Cowardin Code	Alternative B: Proponent's Project[a]	Alternative C: Disconnected Infield Road[a]	Alternative D: Disconnected Access Road	Option 1: Proponent's MTI[b]	Option 2: Point Lonely MTI[b]
L1UBH	–	0.2	–	–	–
PEM1/SS1B	12.8	3.3	4.4	15.6	16.2
PEM1/SS1D	–	9.9	6.4	--	–
PEM1/SS1E	6.6	2.9	–	–	–
PEM1/SS1F	10.0	10	10	–	–
PEM1B	0.6	–	–	–	–
PEM1F	–	2.4	1.7	13.5	13.1
PEM1H	–	0.9	–	–	–
PSS1B	–	–	3.3	–	–
PUBH	–	0.4	–	0.9	0.7
Total	**30.0**	**30.0**	**25.8**	**30.0**	**30.0**

Note: MTI (module transfer island); WOUS (Waters of the U.S.). Cowardin codes are defined in Table E.9.1. Multi-season ice pads (lasting more than one full year in a single location) are considered temporary fill and are subject to U.S. Army Corps of Engineers jurisdiction. Therefore, they are included in the Project's Clean Water Act 404 permit as temporary fill.
[a] Acres are less than Alternative C because the footprint of part of one multi-season ice pad would later be filled with gravel and thus is not counted as temporary ice pad fill.
[b] Data presented are from Wells et al. 2018 and USFWS 2016. All other columns are Wells et al. 2018 only.

Table E.9.4. Direct Wetland Loss by Watershed and Action Alternative

Hydrologic Unit Code (Acres)	Alternative B: Proponent's Project (Acres)	Alternative B: Proponent's Project (% of Watershed)	Alternative C: Disconnected Infield Road (Acres)	Alternative C: Disconnected Infield Road (% of Watershed)	Alternative D: Disconnected Access Road (Acres)	Alternative D: Disconnected Access Road (% of Watershed)
Colville River Delta-Frontal Harrison Bay (224,452.3)	0.9	<0.1	0.9	<0.1	0.9	<0.1
Kalikpik River (233,090.1)	30.1	<0.1	30.1	<0.1	30.1	<0.1
Outlet Fish Creek (137,576.9)	64.6	<0.1	111.5	<0.1	60.1	<0.1
Outlet Judy Creek (246,274.6)	337.6	0.1	336.9	0.1	313.6	0.1
Ublutuoch River (150,954.4)	233.2	0.2	233.2	0.2	229.6	0.2
Total	**666.4**	**NA**	**712.7**	**NA**	**634.4**	**NA**

Note: NA (not applicable). The total acres for each watershed were assumed to be equal to the total wetland acres, since uplands comprise less than 1% of the analysis area. Total acres of direct fill may vary slightly from other resource chapters in the Environmental Impact Statement because those chapters include fill in uplands and this chapter does not.

Table E.9.5. Acres of Wetland Alteration due to Mine Site for All Action Alternatives

Cowardin Code	Direct Alteration	Indirect Dust Shadow
PEM1/SS1B	160.8	109.6
PEM1/SS1D	56.9	31.5
PEM1/SS1E	0.0	0.3
PEM1F	4.2	2.6
PEM1H	1.1	0.4
PSS1B	6.6	4.2
PSS1C	0.0	0.8
PSS3B	0.0	1.1
R2UBH	0.0	0.5
Total	**229.6**	**151.0**
Total in Wetlands[a]	**229.6**	**150.5**

Note: Cowardin codes defined in Table E.9.1.
[a] Fill not in wetlands would be in uplands or freshwater.

Table E.9.6. Acres of Vegetation Damage from Ice Infrastructure by Alternative and Module Delivery Option

Ice Infrastructure	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access Road	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Single-season ice pads	767.6	903.6	982.6	78.0	153.1
Multi-season ice pads	30.0	30.0	25.8	30.0	30.0
Ice roads	2,074.7	2,466.7	3,442.8	1,247.3	2,570.1
Total	**2,872.3**	**3,400.3**	**4,451.2**	**1,355.3**	**2,753.2**

Note: Calculations assume ice road width of 70 feet, and module transfer ice road width ranging from 70 to 120 feet. The total acres indirectly impacted by ice infrastructure were assumed to be equal to wetland acres, since uplands comprise less than 1% of the analysis area. Acres of multi-season ice pads are included in total ice pad acres.

Table E.9.7. Acres of Indirect Dust Shadow by Wetland Type

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access Road
L1UBH	17.7	16.3	17.1
L2EM2H	0.1	0.1	0.1
PEM1/SS1B	942.4	1,012.9	731.7
PEM1/SS1D	902.5	980.2	710.6
PEM1/SS1E	16.8	20.0	13.4
PEM1/SS1F	281.8	329.4	165.7
PEM1F	710.9	632.0	526.0
PEM1H	67.8	72.5	34.6
PEM2H	4.6	5.3	1.4
PSS1/USB	8.2	8.2	8.2
PSS1B	108.2	104.7	103.6
PSS1C	17.8	16.2	17.8
PSS1D	48.3	28.1	46.7
PSS3B	45.6	25.4	45.6
PUBH	65.4	55.6	49.4
R1UBV	1.2	1.2	1.2
R1USQ	1.5	1.5	1.5
R2UBH	7.1	5.1	7.1
R2USC	3.8	1.8	3.8
U	62.8	46.6	62.8
Us	0.9	0.9	0.9
Total	**3,315.6**	**3,363.8**	**2,549.2**
Total in Wetlands[a]	**3,155.1**	**3,234.8**	**2,405.3**
Total in Freshwater WOUS	**96.8**	**81.6**	**80.2**
Total in Uplands	**63.7**	**47.5**	**63.7**

Note: WOUS (waters of the U.S.). Cowardin codes defined in Table E.9.1. Dust shadow is calculated from all gravel infrastructure. Numbers may differ slightly with other reported values in the environmental impact statement due to rounding.
[a] Fill not in wetlands would be in uplands or freshwater WOUS (lakes or rivers).

Table E.9.8. Indirect Impacts (Dust Shadow, Ice Infrastructure) to Wetlands and Waterbodies by Watershed and Action Alternative

Watershed (acres)	Alternative B (acres)	Alternative B (% of watershed)	Alternative C (acres)	Alternative C (% of watershed)	Alternative D (acres)	Alternative D (% of watershed)
Atigaru Point-Frontal Harrison Bay (80,113.4)	0.0	0.0	0.0	0.0	0.0	0.0
Colville River Delta-Frontal Harrison Bay (224,452.3)	35.3	<0.1	35.3	<0.1	35.3	<0.1
Garry Creek-Frontal Harrison Bay (96,450.0)	0.0	0.00	0.0	0.0	0.0	0.0
Kachemach River (145,577.7)	25.0	<0.1	25.0	<0.1	25.0	<0.1
Kalikpik River (233,088.3)	209.6	<0.1	209.6	<0.1	209.6	0.1
Kogru River (91,207.2)	0.0	0.0	0.0	0.0	0.0	0.0
McLeod Point-Frontal Beaufort Sea (55,143.7)	0.0	0.0	0.0	0.0	0.0	0.0
Outlet Fish Creek (137,576.9)	646.1	0.5	855.4	0.6	604.6	0.4
Outlet Judy Creek (246,274.6)	2,828.1	1.2	2,666.4	1.1	2,144.0	0.9
Pogik Bay-Frontal Beaufort Sea (119,840.2)	0.0	0.0	0.0	0.0	0.0	0.0
Smith River (73,275.2)	0.0	0.0	0.0	0.0	0.0	0.0
Teshekpuk Lake (490,483.5)	0.0	0.0	0.0	0.0	0.0	0.0
Ublutuoch River (150,954.4)	431.4	0.9	431.4	0.3	388.3	0.3
Total (2,144,437.4)	**4,175.4**	**NA**	**4,223.0**	**NA**	**3,406.7**	**NA**

Note: NA (not applicable). The total acres for each watershed were assumed to be equal to the total wetland acres, since uplands compose less than 1% of the analysis area. However, numbers may vary slightly from other resource chapters in the EIS because those chapters include fill to uplands and this chapter does not. Dust shadow is calculated from all gravel infrastructure.

Table E.9.9. Indirect Impacts (Dust Shadow, Ice Infrastructure) to Wetlands and Waterbodies by Watershed and Module Delivery Option

Watershed (acres)	Option 1: Proponent's MTI (acres)	Option 1: Proponent's MTI (% of watershed)	Option 2: Point Lonely Island (acres)	Option 2: Point Lonely Island (% of watershed)
Atigaru Point-Frontal Harrison Bay (80,113.4)	237.1	0.3	93.2	0.1
Colville River Delta-Frontal Harrison Bay (224,452.3)	0.0	0.0	0.0	0.0
Garry Creek-Frontal Harrison Bay (96,450.0)	47.8	0.1	94.3	0.1
Kachemach River (145,577.7)	0.0	0.0	0.0	0.0
Kalikpik River (233,088.3)	135.4	0.1	265.1	0.1
Kogru River (91,207.2)	0.0	0.0	164.6	0.2
McLeod Point-Frontal Beaufort Sea (55,143.7)	0.0	0.0	6.2	<0.1
Outlet Fish Creek (137,576.9)	118.5	0.1	153.3	0.1
Outlet Judy Creek (246,274.6)	151.1	0.1	151.1	0.1
Pogik Bay-Frontal Beaufort Sea (119,840.2)	0.0	0.0	87.2	0.1
Smith River (73,275.2)	0.0	0.0	185.7	0.3
Teshekpuk Lake (490,483.5)	0.0	0.0	18.3	<0.1
Ublutuoch River (150,954.4)	32.6	<0.1	32.7	<0.1
Total (2,144,437.4)	**722.5**	**NA**	**1,251.7**	**NA**

Note: MTI (module transfer island); NA (not applicable). The total acres for each watershed were assumed to be equal to the total wetland acres, since uplands comprise less than 1% of the analysis area. However, numbers may vary slightly from other resource chapters in the Environmental Impact Statement because those chapters include fill to uplands and this chapter does not. Dust shadow is calculated from all gravel infrastructure.

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Willow Master Development Plan

Appendix E.10
Fish Technical Appendix

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List of Acronyms

Project	Willow Master Development Plan Project

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1.0 FISH AND AQUATIC HABITAT

1.1 Species

Table E.10.1 details the fish species that use the analysis area.

Table E.10.1. Fish Species that Use the Analysis Area

Family or Subfamily	Common Name	Scientific Name	Habitat Use	Wintering Habitat
Mudminnows	Alaska blackfish[a]	*Dallia pectoralis*	Freshwater	Freshwater lakes and streams
Smelts	Capelin	*Mallotus villosus*	Marine	Marine
Smelts	Rainbow smelt	*Osmerus mordax*	Anadromous	Marine/Brackish waters
Salmonids	Arctic cisco	*Coregonus autumnalis*	Anadromous	Freshwater lakes and streams, brackish waters
Salmonids	Bering cisco	*Coregonus laurettae*	Anadromous	Brackish waters and river mouths
Salmonids	Broad whitefish[b]	*Coregonus nasus*	Anadromous	Freshwater lakes and streams
Salmonids	Humpback whitefish[b]	*Coregonus pidschian*	Anadromous	Freshwater lakes and streams
Salmonids	Least cisco[b]	*Coregonus sardinella*	Anadromous	Freshwater lakes and streams
Salmonids	Round whitefish[b]	*Prosopium cylindraceum*	Freshwater	Freshwater lakes and streams
Salmonids	Arctic grayling[b]	*Thymallus arcticus*	Freshwater	Freshwater lakes and streams
Salmonids	Pink salmon[c]	*Oncorhynchus gorbuscha*	Anadromous	Freshwater streams[d]
Salmonids	Chum salmon[c]	*Oncorhynchus keta*	Anadromous	Freshwater streams[d]
Salmonids	Sockeye salmon[c]	*Oncorhynchus nerka*	Anadromous	Freshwater streams[d]
Salmonids	Chinook salmon[c]	*Oncorhynchus tshawytscha*	Anadromous	Freshwater streams[d]
Salmonids	Lake trout[b]	*Salvelinus namaycush*	Freshwater	Freshwater lakes and streams
Salmonids	Dolly Varden	*Salvelinus malma*	Anadromous	Freshwater lakes and streams
Cods	Burbot[b]	*Lota lota*	Freshwater	Freshwater lakes and streams
Cods	Arctic cod[c]	*Boreogadus saida*	Marine	Marine
Cods	Saffron cod	*Eleginus gracilis*	Marine	Marine
Sticklebacks	Threespine stickleback	*Gaterosteus aculeatus*	Anadromous	Freshwater lakes and streams
Sticklebacks	Ninespine stickleback[a]	*Pungitius pungitius*	Anadromous	Freshwater lakes and streams
Sculpins	Slimy sculpin	*Cottus cognatus*	Freshwater	Freshwater lakes and streams
Sculpins	Fourhorn sculpin	*Myoxocephalus quadricornis*	Marine	Marine/Brackish waters
Right-eye flounders	Arctic flounder	*Liopsetta glacialis*	Marine	Marine

Note: Freshwater fish use primarily freshwater habitats; however, many freshwater fish can tolerate low-salinity waters and therefore may move into nearshore areas as conditions allow. Anadromous fish spend a portion of their life cycle in both fresh and marine waters and may move between such habitats for spawning. Marine fish use primarily marine and estuarine waters.

[a] Common in freshwater lakes of the Willow area – considered resistant to changes in water quality per Best Management Practice (BMP) B-2.

[b] Common or known to occur in freshwater lakes of the Willow area – considered sensitive to changes in water quality per BMP B-2.

[c] Species with designated Essential Fish Habitat in the analysis area.

[d] Only egg and alevin overwintering habitat; no known juvenile salmon overwintering habitat has been documented in the analysis area.

1.2 Comparison of Alternatives: Fish

Table E.10.2 details Willow Master Development Plan Project (Project) components that affect fish or Essential Fish Habitat.

Table E.10.2. Comparison of Project Components that May Affect Fish by Action Alternative

Project Component	Alternative B: Proponent's Proposal	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access
Bridges (number)	7	6	6
Culvert batteries (number)	11	10	8
Piles below OHW (number)	56	36	52
VSMs below OHW (number)	14	32	14
Aquatic habitat filled by piles and VSMs (square feet)	622.0	656.2	594.0
Freshwater EFH filled by piles and VSMs (square feet)[a]	440.3	474.5	440.3
Onshore ice road (miles)	372.0	471.0	694.5
Fill in fish-bearing lakes (acres/number of lakes affected)	0/0	0/0	0/0
Fill in lakes with unknown fish presence (acres/number of lakes affected)	<0.1/1	0.3/4	0/0
Number of fish-bearing lakes within 500 feet of permanent infrastructure (BMP LS E-2)	2	3	2
Number of lakes with unknown fish presence within 500 feet of permanent infrastructure (BMP LS E-2)	10	11	9
Dust shadow in fish-bearing lakes (acres/number of lakes affected)	4.1/2	3.9/1	4.1/2
Dust shadow in lakes with unknown fish presence (acres/number of lakes affected)	13.6/15	12.7/14	12.9/14
Freshwater use (millions of gallons)	1,874.0	2,047.2	2,433.8

Note: BMP (best management practice); OHW (ordinary high water); VSMs (vertical support members); EFH (essential fish habitat); < (less than)
[a] Included in row above (total aquatic habitat filled).

Willow Master Development Plan

Appendix E.11
Birds Technical Appendix

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Table of Contents

List of Tables

List of Acronyms

ACP	Arctic Coastal Plain
BLM	Bureau of Land Management
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
USFWS	U.S. Fish and Wildlife Service

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1.0 BIRDS

1.1 Bird Species and Habitats

Table E.11.1 summarizes bird species and habitat use in the analysis area.

Table E.11.1. Bird Species that may Occur in the Analysis Area

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Waterfowl	Greater white-fronted goose	*Anser albifrons*	Common	Breeder	SAMA, TLHC, DOWIP, SOW, SOWIP, SEMA, DPC, YBWC, OBWC, NPWM, PWM, MSSM, MTT, TLDS	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Rozell and Johnson 2016; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003
Waterfowl	Snow goose[c]	*Anser caerulescens*	Common	Breeder	ONW, BRWA, SAMA, TFB, TLLC, TLHC, DOW, DOWIP, SOW, SEMA, DPC, GRMA, OBWC, NPWM, PWM, MSSM, MTT, TLDS, BAR[b]	Johnson, Wildman et al. 2012, 2013; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Mowbray, Cooke et al. 2000; Johnson, Burgess et al. 2004; Burgess, Johnson et al. 2013
Waterfowl	Brant	*Branta bernicla*	Common	Breeder	TLLC, TLHC, DOWIP, SOW, SOWIP, RS, DPC, YBWC, OBWC, NPWM, PWM, BAR	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Wildman et al. 2012, 2013; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Day, Prichard et al. 2005; Johnson, Burgess et al. 2004; Burgess, Johnson et al. 2013
Waterfowl	Canada goose	*Branta canadensis*	Common	Breeder	DOW, DOWIP, SOW, SOWIP, SEMA, YBWC, OBWC, NPWM, PWM	Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Rozell and Johnson 2016; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2013
Waterfowl	Tundra swan	*Cygnus columbianus*	Common	Breeder	BRWA, SAMA, TFB, TLLC, TLHC, DOW, DOWIP, SOW, RS, SEMA, DPC, GRMA, YBWC, OBWC, NPWM, PWM, MSSM, MTT, TLDS, BAR	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Jorgenson, ConocoPhillips Alaska et al. 2004; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2005
Waterfowl	Gadwall	*Mareca strepera*	Casual	Visitor	NA[e]	Johnson and Herter 1989
Waterfowl	American wigeon	*Mareca americana*	Uncommon	Breeder	SEMA, PWM	Rothe, Markon et al. 1983
Waterfowl	Mallard	*Anas platyrhynchos*	Uncommon	Breeder	YBWC, PWM	Johnson, Burgess et al. 2005; Burgess, Johnson et al. 2003
Waterfowl	Northern shoveler	*Spatula clypeata*	Uncommon	Breeder	SEMA, GRMA, NPWM, PWM, MSSM	Johnson, Burgess, Lawhead, Neville et al. 2003; Rothe, Markon et al. 1983; Burgess, Johnson et al. 2003
Waterfowl	Northern pintail	*Anas acuta*	Common	Breeder	SEMA, DPC, NPWM, PWM, MSSM, MTT, TLDS, BAR	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Rozell and Johnson 2016; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2003
Waterfowl	Green-winged teal	*Anas crecca*	Uncommon	Breeder	SEMA, DPC, PWM, MSSM, MTT, TLDS	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Rozell and Johnson 2016; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2003

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Waterfowl	Canvasback	*Aythya valisineria*	Casual	Visitor	NA[e]	Johnson and Herter 1989
Waterfowl	Greater scaup	*Aythya marila*	Uncommon	Breeder	ONW, SEMA, DPC, GRMA, YBWC, NPWM, PWM, MSSM	Johnson, Burgess, Lawhead, Neville et al. 2003; Lysne, Mallek et al. 2004; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2003
Waterfowl	Lesser scaup	*Aythya affinis*	Rare	Breeder	ONW, NPWM	Lysne, Mallek et al. 2004; Johnson, Burgess et al. 2004
Waterfowl	**Steller's eider**	***Polysticta stelleri***	**Casual**	**Visitor**	**SOWIP, SEMA, YBWC, OBWC, GRMA, NPWM, PWM, MSSM**	**Graff 2016; Quakenbush, Suydam et al. 2000; Safine 2013, 2015**
Waterfowl	**Spectacled eider**	***Somateria fischeri***	**Uncommon**	**Breeder**	**ONW, BRWA, SAMA, SKT, TLHC, DOW, DOWIP, SOW, SOWIP, DPC, GRMA, YBWC, OBWC, NPWM, PWM**	**Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Anderson, Ritchie et al. 1999; Johnson, Parrett et al. 2008; Fischer and Larned 2004; Johnson, Burgess et al. 2005; Burgess, Johnson et al. 2003**
Waterfowl	King eider	*Somateria spectabilis*	Common	Breeder	ONW, BRWA, SAMA, TLLC, DOW, DOWIP, SOW, SOWIP, RS, SEMA, DPC, GRMA, YBWC, OBWC, NPWM, PWM, MSSM	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Rozell and Johnson 2016; Fischer and Larned 2004; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2013
Waterfowl	Common eider[d]	*Somateria mollissima*	Uncommon	Breeder	ONW, BAR[d]	Fischer and Larned 2004; Johnson 2000; LGL Alaska Research Associates Inc. 2002
Waterfowl	Surf scoter	*Melanitta perspicillata*	Common	Breeder	ONW	Johnson and Herter 1989; Lysne, Mallek et al. 2004
Waterfowl	White-winged scoter	*Melanitta fusca*	Common	Breeder	ONW	Johnson and Herter 1989; Lysne, Mallek et al. 2004
Waterfowl	Black scoter	*Melanitta americana*	Casual	Visitor	ONW	Johnson and Herter 1989; Lysne, Mallek et al. 2004
Waterfowl	Long-tailed duck	*Clangula hyemalis*	Common	Breeder	ONW, BRWA, DOW, DOWIP, SOW, SOWIP, SEMA, DPC, GRMA, YBWC, OBWC, NPWM, PWM, MSSM, MTT, TLDS, RS	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Fischer and Larned 2004; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2004, 2005; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003
Waterfowl	Red-breasted merganser	*Mergus serrator*	Rare	Breeder	DOW, DOWIP, SOWIP	Johnson, Burgess et al. 2004; ABR Unpubl. data
Loons and grebes	Red-necked grebe	*Podiceps grisegena*	Rare	Breeder	TLHC, DOW, SEMA, GRMA[f]	Johnson, Burgess, Lawhead, Neville et al. 2003; Rothe, Markon et al. 1983
Loons and grebes	**Red-throated loon**	***Gavia stellata***	**Common**	**Breeder**	**ONW, BRWA, SAMA, SOWIP, DPC, OBWC, RICO, NPWM, PWM[f]**	**Johnson, Burgess, Lawhead, Neville et al. 2003; Day, Prichard et al. 2005; Fischer and Larned 2004; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2004; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003**
Loons and grebes	Pacific loon	*Gavia pacifica*	Common	Breeder	ONW, BRWA, SAMA, TLHC, DOW, DOWIP, SOW, SOWIP, SEMA, DPC, GRMA, OBWC, RICO, NPWM, PWM, MSSM, HUMO[f]	Johnson, Burgess, Lawhead, Neville et al. 2003; Day, Prichard et al. 2005; Rozell and Johnson 2016; Kertell 1996; Fischer and Larned 2004; Rothe, Markon et al. 1983; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Loons and grebes	Common loon	*Gavia immer*	Casual/Accidental	Visitor	NA[e]	–
Loons and grebes	**Yellow-billed loon**	***Gavia adamsii***	**Common**	**Breeder**	**ONW, TLHC, DOW, DOWIP, SOWIP, SEMA, DPC, GRMA, NPWM, PWM, MSSM [f]**	**Johnson, Burgess, Lawhead, Neville et al. 2003; Fischer and Larned 2004; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Day, Prichard et al. 2005; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2004**
Seabirds	Pomarine jaeger	*Stercorarius pomarinus*	Uncommon	Visitor	NA[e]	Johnson and Herter 1989
Seabirds	Parasitic jaeger	*Stercorarius parasiticus*	Uncommon	Breeder	SEMA, YBWC, OBWC, DPC, NPWM, PWM, MSSM, RICO	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Jorgenson, ConocoPhillips Alaska et al. 2004; Day, Prichard et al. 2005; Rozell and Johnson 2016; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003
Seabirds	Long-tailed jaeger	*Stercorarius longicaudus*	Uncommon	Breeder	OBWC, NPWM, PWM, MSSM, MTT	Johnson, Burgess, Lawhead, Neville et al. 2003; Anderson, Lawhead et al. 2001; Day, Prichard et al. 2005; Johnson, Burgess et al. 2004; Burgess, Johnson et al. 2003
Seabirds	Black guillemot	*Cepphus grylle*	Rare	Visitor	ONW	Johnson and Herter 1989
Seabirds	Black-legged kittiwake	*Rissa tridactyla*	Rare	Visitor	ONW	Johnson and Herter 1989
Seabirds	Sabine's gull	*Xema sabini*	Uncommon	Breeder	ONW, BRWA, SAMA, DOW, DOWIP, SOWIP, SEMA, DPC, OBWC, NPWM, MSSM, SKT, BAR	Day, Prichard et al. 2005; Day, Stenhouse et al. 2001; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Burgess et al. 2004; Johnson, Parrett et al. 2015; Rozell and Johnson 2016
Seabirds	Herring gull	*Larus argentatus*	Casual/ Accidental	Visitor	NA[e]	Johnson and Herter 1989
Seabirds	Thayer's gull	*Larus thayeri*	Casual/ Accidental	Visitor	NA[e]	Johnson and Herter 1989
Seabirds	Glaucous-winged gull	*Larus glaucescens*	Casual/ Accidental	Visitor	NA[e]	Johnson and Herter 1989
Seabirds	Glaucous gull	*Larus hyperboreus*	Common	Breeder	ONW, BRWA, TFB, TLLC, TLHC, DOWIP, SOW, SOWIP, SEMA, YBWC, OBWC, BAR, DPC	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess et al. 2004; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003
Seabirds	**Arctic tern**	***Sterna paradisaea***	**Common**	**Breeder**	**ONW, SKT, SAMA, TLHC, DOW, DOWIP, SOWIP, SOW, SEMA, DPC, YBWC, OBWC, NPWM, PWM, MSSM**	**Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess et al. 2004; Johnson, Burgess et al. 2002; Burgess, Johnson et al. 2003**
Shorebirds	Black-bellied plover	*Pluvialis squatarola*	Common	Breeder	OBWC, DUCO, PWM, MSSM	Andres 1989; Rothe, Markon et al. 1983
Shorebirds	American golden-plover	*Pluvialis dominica*	Common	Breeder	SAMA, DPC, PWM, MSSM, MTT, TLDS	Andres 1989; Brown, Bart et al. 2007; Meehan 1986; Rothe, Markon et al. 1983; Taylor, Lanctot et al. 2010
Shorebirds	Semipalmated plover	*Charadrius semipalmatus*	Uncommon	Breeder	BAR, HUMO	Johnson and Herter 1989

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Shorebirds	Upland sandpiper	*Bartramia longicauda*	Casual/ Accidental	Visitor	NA[e]	Johnson and Herter 1989
Shorebirds	**Whimbrel**	***Numenius phaeopus***	**Rare**	**Breeder**	**PWM**	**Burgess, Johnson et al. 2003**
Shorebirds	**Bar-tailed godwit**	***Limosa lapponica***	**Uncommon**	**Breeder**	**NPWM, PWM, MSSM, MTT, TLDS**	**Burgess, Johnson et al. 2003; Day, Prichard et al. 2005; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Burgess et al. 2004; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; McCaffery and Gill 2001**
Shorebirds	Ruddy turnstone	*Arenaria interpres*	Uncommon	Breeder	SKT, DPC, NPWM, PWM	Andres 1989; Johnson and Herter 1989
Shorebirds	**Red knot**	***Calidris canutus***	**Rare**	**Visitor**	**NA[e]**	**Johnson and Herter 1989**
Shorebirds	Stilt sandpiper	*Calidris himantopus*	Common	Breeder	YBWC, OBWC, PWM, NPWM	Andres 1989; LGL Alaska Research Associates Inc. 1988
Shorebirds	Sanderling	*Calidris alba*	Rare	Visitor	NA[e]	Johnson and Herter 1989
Shorebirds	**Dunlin**	***Calidris alpina***	**Common**	**Breeder**	**SAMA, TFB, SEMA, YBWC, OBWC, NPWM, PWM, MSSM**	**Andres 1989; LGL Alaska Research Associates Inc. 1988; Taylor, Lanctot et al. 2010**
Shorebirds	Baird's sandpiper	*Calidris bairdii*	Rare	Breeder	MSSM, TLDS, BAR, MTT	Moskoff and Montgomerie 2002
Shorebirds	Least sandpiper	*Calidris minutilla*	Casual/ Accidental	Visitor	NA[e]	Johnson and Herter 1989
Shorebirds	White-rumped sandpiper	*Calidris fuscicollis*	Rare	Breeder	NPWM, PWM, MSSM, TLDS	Parmelee 1992
Shorebirds	**Buff-breasted sandpiper**	***Calidris subruficollis***	**Rare**	**Breeder**	**NPWM, MSSM, MTT, TLDS, BAR**	**Lanctot and Laredo 1994**
Shorebirds	Pectoral sandpiper	*Calidris melanotos*	Common	Breeder	SAMA, SEMA, GRMA, DPC, YBWC, OBWC, NPWM, PWM, MSSM, BAR	Andres 1989; Brown, Bart et al. 2007; LGL Alaska Research Associates Inc. 1988; Taylor, Lanctot et al. 2010
Shorebirds	Semipalmated sandpiper	*Calidris pusilla*	Common	Breeder	SAMA, TFB, DPC, YBWC, OBWC, NPWM, PWM, MSSM	Andres 1989; LGL Alaska Research Associates Inc. 1988; Rothe, Markon et al. 1983; Taylor, Lanctot et al. 2010
Shorebirds	Western sandpiper	*Calidris mauri*	Casual/ Accidental	Visitor	SAMA, PWM	Andres 1989; Taylor, Lanctot et al. 2010
Shorebirds	Long-billed dowitcher	*Limnodromus scolopaceus*	Common	Breeder	SAMA, SEMA, YBWC, OBWC, NPWM, PWM	Andres 1989; Takekawa and Warnock 2000; Taylor, Lanctot et al. 2010
Shorebirds	Wilson's snipe	*Gallinago delicata*	Uncommon	Breeder	YBWC, OBWC, NPWM, PWM, MSSM	Johnson, Burgess, Lawhead, Neville et al. 2003
Shorebirds	Lesser yellowlegs	*Tringa flavipes*	Rare	Breeder	NA[e]	Johnson and Herter 1989
Shorebirds	Red-necked phalarope	*Phalaropus lobatus*	Common	Breeder	ONW, SAMA, SEMA, DPC, GRMA, YBWC, OBWC, NPWM, PWM, MSSM, HUMO	Andres 1989; Brown, Bart et al. 2007; LGL Alaska Research Associates Inc. 1988; Rothe, Markon et al. 1983; Rubega, Schamel et al. 2000

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Shorebirds	Red phalarope	*Phalaropus fulicarius*	Common	Breeder	ONW, SAMA, SEMA, DPC, GRMA, YBWC, OBWC, NPWM, PWM	Andres 1989; Brown, Bart et al. 2007; LGL Alaska Research Associates Inc. 1988; Tracy, Schamel et al. 2002
Cranes	Sandhill crane	*Mareca americana*	Uncommon	Breeder	SEMA, GRMA, NPWM, PWM	Gerber, Dwyer et al. 2014; Johnson, Parrett et al. 2014; Johnson, Lawhead et al. 1998
Raptors	Bald eagle	*Haliaeetus leucocephalus*	Rare	Visitor	NA[e]	Johnson and Herter 1989
Raptors	Northern harrier	*Circus hudsonius*	Rare	Breeder	NPWM, PWM, MSSM, TLDS	Smith, Wittenberg et al. 2011; Burgess, Johnson et al. 2003
Raptors	Rough-legged hawk	*Buteo lagopus*	Uncommon	Breeder	MSSM, MTT, HUMO	Johnson and Herter 1989; Ritchie 1991
Raptors	Golden eagle	*Aquila chrysaetos*	Uncommon	Visitor	NA[e]	Johnson and Herter 1989
Raptors	Snowy owl	*Bubo scandiacus*	Uncommon	Breeder	OBWC, PWM, NPWM	Holt, Larson et al. 2015; Burgess, Johnson et al. 2013
Raptors	Short-eared owl	*Asio flammeus*	Uncommon	Rare Breeder	NPWM, PWM, MSSM, MTT, TLDS	Johnson, Burgess et al. 2001; Johnson, Burgess et al. 2002; Johnson, Burgess, Lawhead, Parrett et al. 2003
Raptors	Merlin	*Falco columbarius*	Rare	Visitor	NA[e]	Johnson and Herter 1989
Raptors	Gyrfalcon	*Falco rusticolus*	Rare	Visitor	NA[e]	Johnson, Parrett et al. 2014
Raptors	**Arctic peregrine falcon**	***Falco peregrinus tundrius***	**Uncommon**	**Rare Breeder**	**TLDS, HUMO**	**Johnson, Wildman et al. 2013**
Ptarmigan	Willow ptarmigan	*Lagopus*	Common	Breeder	DPC, OBWC, NPWM, PWM, MSSM, MTT, TLDS	Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Jorgenson, ConocoPhillips Alaska et al. 2004; Rothe, Markon et al. 1983; Johnson, Burgess et al. 2005; Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003
Ptarmigan	Rock ptarmigan	*Lagopus muta*	Uncommon	Breeder	PWM, MSSM, MTT, TLDS	Johnson, Burgess, Lawhead, Neville et al. 2003; Rothe, Markon et al. 1983; Burgess, Johnson et al. 2003
Passerines	Common raven	*Corvus corax*	Uncommon (except common around infrastructure)	Breeder	HUMO	Johnson, Lawhead et al. 1998; Powell and Backensto 2009
Passerines	Arctic warbler	*Phylloscopus borealis*	Rare	Breeder	TLDS	Johnson and Herter 1989; Lowther and Sharbaugh 2014
Passerines	Bluethroat	*Luscinia svecica*	Casual/ Accidental	Visitor	TLDS	Guzy and McCaffery 2002; Johnson and Herter 1989
Passerines	Gray-cheeked thrush	*Catharus minimus*	Casual/ Accidental	Visitor	TLDS	Johnson and Herter 1989; Lowther, Rimmer et al. 2001
Passerines	Eastern yellow wagtail	*Motacilla tschutschensis*	Uncommon	Breeder	MSSM, MTT, TLDS	Badyaev, Kessel et al. 1998; Johnson and Herter 1989

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Passerines	Redpoll	*Acanthis flammea and A. hornemanni*	Uncommon	Breeder	MSSM, TLDS	Johnson and Herter 1989; Knox and Lowther 2000a, 2000
Passerines	Lapland longspur	*Calcarius lapponicus*	Common	Breeder	NPWM, PWM, MSSM, MTT	Hussell and Montgomerie 2002
Passerines	Snow bunting	*Plectrophenax nivalis*	Uncommon (except common around infrastructure)	Breeder	BAR, HUMO	Montgomerie and Lyon 2011
Passerines	American tree sparrow	*Spizelloides arborea*	Uncommon	Breeder	TLDS	Johnson and Herter 1989; Naugler, Pyle et al. 2017
Passerines	Savannah sparrow	*Passerculus sandwichensis*	Common	Breeder	DPC, NPWM, PWM, MSSM, MTT	Johnson and Herter 1989; Wheelwright and Rising 2008
Passerines	Fox sparrow	*Passerella iliaca*	Casual/ Accidental	Visitor	TLDS	Weckstein, Kroodsma, and Faucett 2002
Passerines	Lincoln's sparrow	*Melospiza lincolnii*	Casual/ Accidental	Visitor	TLDS	Ammon 1995
Passerines	White-crowned sparrow	*Zonotrichia leucophrys*	Rare	Breeder	TLDS	Chilton, Baker et al. 1995; Johnson and Herter 1989

Note: BAR (Barren); BRWA (Brackish Water); DOW (Deep Open Water without Islands); DOWIP (Deep Open Water with Islands or Polygonized Margins); DPC (Deep Polygon Complex); DUCO (Dune Complex); GRMA (Grass Marsh); HUMO (Human Modified); MSSM (Moist Sedge-Shrub Meadow); MTT (Moist Tussock Tundra); NPWM (Nonpatterned Wet Meadow); NA (not applicable); OBWC (Old Basin Wetland Complex); ONW (Open Nearshore Water); PWM (Patterned Wet Meadow); RICO (Riverine Complex); RS (River or Stream); SAMA (Salt Marsh); SEMA (Sedge Marsh); SKT (Salt-Killed Tundra); SOW (Shallow Open Water without Islands); SOWIP (Shallow Open Water with Islands or Polygonized Margins); TFB (Tidal Flat Barrens); TLDS (Tall, Low, or Dwarf Shrub); TLHC (Tapped Lake with High-water Connection); TLLC (Tapped Lake with Low-water Connection); YBWC (Young Basin Wetland Complex). Habitats are defined in Willow MDP EIS, Chapter 3.9, *Wetlands and Vegetation*, and Table E.11.2 below. Shading denotes species that may use the analysis area year-round. Bolding denotes special status species.

[a] Common—occurs in all or nearly all proper habitats, but some areas are occupied sparsely or not at all; uncommon—occurs regularly but uses little of the suitable habitat or occurs regularly in relatively small numbers; rare—occurs within normal range, regularly, in very small numbers; casual—beyond its normal range but irregular observations are likely over years; accidental—so far beyond its normal range that future observations are unlikely (Johnson and Herter 1989).

[b] Primarily nesting habitats but includes pre-breeding, brood-rearing, and post-breeding habitats for species whose preference or use varies markedly between these periods (e.g., brant, snow goose, and shorebirds). Preference based on selection analyses, where available; in absence of selection analyses, based on use of nesting, brood-rearing, and post-breeding habitat from literature. Habitats that occur in the Willow Project vicinity are listed in the table.

[c] Snow goose colonies tend to be on the coast; they initially colonize river deltas on the ACP. They spread across a variety of habitats during expansion. Initially found on raised areas, where snow melts early but is not subject to flooding, thus unvegetated and partially vegetated BAR, TLDS, NPWM, PWM, and DPC.

[d] Common eiders nest on coastal barrier islands, sandspits, and partially vegetated beaches along the Beaufort Sea coast.

[e] No records of nesting or no nesting habitat described for the central Beaufort Sea coast.

[f] Pacific, red-throated, and yellow-billed loons and red-necked grebes nest on shorelines of waterbodies; terrestrial habitats in the table refer to the shoreline habitat bordering a waterbody.

1.1.1 Special Status Species

Spectacled eiders occur in the analysis area during pre-breeding and may nest there in low numbers. Surveys conducted at 50% coverage for the Willow Master Development Plan Project (Project) detected two groups of spectacled eiders in 2017 and five groups in 2018 (Figure 3.11.2), resulting in indicated total densities of 0.03 and 0.08 birds per square mile, respectively (0.01 and 0.03 birds per square kilometer) (Johnson, Parrett et al. 2018b, 2019). The density of spectacled eiders from those latest surveys is approximately 10% to 30% of densities found on the Colville River Delta and the entire Arctic Coastal Plain (ACP) (Figure 4 in Johnson et al. 2018c). Based on the estimated density of pre-breeding spectacled eiders (0.08 birds per square mile) and the amount of preferred eider habitat permanently lost to gravel infrastructure (32.8 acres [0.05 square miles]), Alternative B could result in the loss or displacement of 0.004 spectacled eiders annually. Assuming a single nest is produced by each pair of birds, 0.002 spectacled eider nests could be lost or displaced each year by gravel infrastructure. Approximately 0.07 nests could be lost or displaced within the 656-foot (200 meters) disturbance zone around gravel and pipeline infrastructure.

Seven additional species of birds listed as special status species by the Bureau of Land Management (BLM)—yellow-billed loon, red-throated loon, dunlin, bar-tailed godwit, whimbrel, buff-breasted sandpiper, and red knot—may also occur in the analysis area (BLM 2019). The U.S. Fish and Wildlife Service (USFWS) list of species of conservation concern includes the seven species on the BLM list above plus peregrine falcon and arctic tern. Of these special status species, red knot is a rare to casual visitor, buff-breasted sandpiper, whimbrel, and peregrine falcon are rare breeders, and the remaining species are common to uncommon breeders in the analysis area.

In addition to being a Bird of Conservation Concern, the yellow-billed loon was a candidate for listing under the Endangered Species Act because of its small population size, patchy breeding distribution, and possible threats to its population viability in Alaska (USFWS 2014b) until listing of the species was ruled unwarranted in 2014 (USFWS 2014a). A conservation plan for yellow-billed loons was adopted by federal, state, and local governments (USFWS 2006). The yellow-billed loon is distributed unevenly on the ACP, occurring in the NPR-A east to approximately the Colville River Delta (Earnst 2004; Earnst, Stehn et al. 2005). The NPR-A supports >75% of the U.S. breeding population (Schmutz, Wright et al. 2014). Yellow-billed loons are common breeders in the analysis area; surveys conducted since 2001 have detected 28 breeding territories encompassing 32 lakes within approximately 3 miles of the Project (Johnson, Parrett et al. 2018b, 2019). Yellow-billed loons maintain territories on the same lakes for several decades (Johnson, Parrett et al. 2019) and are habitat specialists, preferring deep, clear, open lakes, and deep lakes with emergent vegetation containing fish (Earnst, Platte et al. 2006; Haynes, Schmutz et al. 2014), nesting most often on islands and peninsulas protected from wave action (North and Ryan 1989; Haynes, Schmutz et al. 2014).

1.1.2 Bird Habitats

Bird habitats and use in the analysis area is detailed in Table E.11.2. Table E.11.3 summarizes preferred habitat for spectacled eiders.

Table E.11.2. Descriptions and Use of Bird Habitats in the Analysis Area

Habitat[a]	Description	No. of Species Using	Acres in Analysis Area
Dune Complex	Mosaic of swale and ridge features on inactive sand dunes, supporting wet to flooded sedge and moist shrub types in swales and moist to dry dwarf and low shrub types on ridges	1	1,830.0
Riverine Complex	Mosaic of moist to wet sedge and shrub types, water, and barrens along flooded streams and associated floodplains	3	978.6
Salt-Killed Tundra	Coastal low-lying areas where saltwater from storm surges has killed the original vegetation and is being colonized by salt-tolerant vegetation	3	164.9
River or Stream	Permanently flooded channels large enough to be mapped as separate units	4	7,513.1
Tapped Lake with Low-Water Connection	Same as above except connected to adjoining surface waters even at low water	5	2,199.2
Tidal Flat Barrens	Nearly flat, barren mud or sand periodically inundated by tidal waters; may include small areas of partially vegetated mud or sand	6	32.6
Human Modified	Area with vegetation, soil, or water significantly disturbed by human activity	7	471.6
Tapped Lake with High-Water Connection	Lakes that were breached and drained by a migrating river channel and by permafrost thaw. Tapped lakes subject to river stages and discharge, connected only during flood or high-water events.	9	4,415.5
Brackish Water	Coastal ponds and lakes that are flooded periodically by saltwater during storm surges	10	148.9
Deep Open Water without Islands	Waterbody lacking emergent vegetation with a depth of at least 6.6 feet (2 meters)	11	24,996.3
Shallow Open Water without Islands	Waterbodies lacking emergent vegetation with depths less than 6.6 feet (2 meters)	11	4,300.2
Barren	Area without vegetation and not normally inundated	12	9,555.3
Deep Open Water with Islands or Polygonized Margins	Waterbodies with depths of at least 6.6 feet (2 meters) with islands or with polygonized wetlands forming a complex shoreline	14	20,202.1
Shallow Open Water with Islands or Polygonized Margins	Waterbodies lacking emergent vegetation with depths less than 6.6 feet (2 meters) with islands or with **polygonized wetlands** forming a complex shoreline (Willow MDP EIS, Chapter 3.9, *Wetlands and Vegetation*).	14	3,784.7
Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva* (pendant grass). Shallow water depths (less than 3.3 feet [1 meter]). Tends to have abundant invertebrates, good escape cover for birds, and high importance to many waterbirds.	15	1,649.9
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation dominated by tussock-forming plants, most commonly *Eriophorum vaginatum*. Associated with high-centered polygons of low or high relief.	18	86,326.5
Salt Marsh	Complex assemblage of small brackish ponds, halophytic sedges and willows, and barren patches on stable mudflats usually associated with river deltas	21	1,055.1
Young Basin Wetland Complex	Complex ice-poor, drained lake thaw basins characterized by a complex mosaic of vegetation classes that, in general, have surface water with a high percentage of Fresh Sedge Marsh and Fresh Grass Marsh	21	1,036.1
Open Nearshore Water	Shallow estuaries, lagoons, and embayments along the Beaufort Sea coast	22	181.5
Deep Polygon Complex	Area permanently flooded with water more than 1.6 feet (≤0.5 meter) deep, frequently with emergent sedge in margins, deep polygon centers, and well-developed polygon rims	25	1,209.0
Sedge Marsh	Permanently flooded waterbodies dominated by the emergent sedge *Carex aquatilis*. Typically, emergent sedges occur in water <1.6 feet (≤0.5 meter) deep.	25	7,232.1
Tall, Low, or Dwarf Shrub	Both open and closed stands of low (≤4.9 feet [1.5 meters] high) and tall (>4.9 feet [1.5 meters] high) willows along riverbanks and Dryas Tundra on upland ridges and stabilized sand dunes	25	22,598.0
Old Basin Wetland Complex	Complex ice-rich habitat in older drained lake basins with well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice.	27	19,993.5

Habitat[a]	Description	No. of Species Using	Acres in Analysis Area
Moist Sedge-Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and deposits formed by the movement of soil and other material. Soils saturated at intermediate depths (>0.5 feet [>0.15 meter]) but generally free of surface water during summer.	36	53,398.5
Nonpatterned Wet Meadow	Analogous to sedge meadow or shrub meadow. Lowland areas, typically flooded in spring, but lacking polygons or other terrain relief features.	39	17,774.8
Patterned Wet Meadow	Lowland areas with low-centered polygons that are flooded in spring, centers flooded or with water remaining close to the surface throughout the growing season. Vegetation growth typically is more robust in polygon troughs than in centers.	44	55,186.7
Unmapped	Unknown	–	545,742.6
Total	–	**–**	**893,977.5**

Source: See sources for Table E.11.1. As described in Section 3.11.1.2, *Bird Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for avian occurrence. Actual scores ranged from 1 (one species used the habitat) to 44 (44 species used the habitat). Shading denotes high-use habitats (at least 20 species use the habitat). See Table E.11.1 for more details on habitat values.

[a] More information on these habitat types is provided in Willow MDP EIS, Chapter 3.9, *Wetlands and Vegetation*.

Table E.11.3. Spectacled Eider Habitat Preference and Use

Habitat	NE NPR-A Pre-breeding Use (%)[b]	NE NPR-A Pre-breeding Availability (%)	NE NPR-A Pre-breeding Preference[c]	Colville Pre-breeding Use (%)[b]	Colville Pre-breeding Availability (%)	Colville Pre-breeding Preference[c]	NE NPR-A Nesting[a] Use (%)	Colville Nesting[a] Use (%)
Open Nearshore Water	1.7	0.3	ns	0.2	1.6	avoid	–	–
Brackish Water	**11.7**	**0.3**	**prefer**	**6.7**	**1.3**	**prefer**	–	**4.0**
Tapped Lake with Low-Water Connection	0	0.2	ns	2.9	4.5	avoid	–	–
Tapped Lake with High-Water Connection	0	<0.1	ns	2.2	3.7	ns	–	**1.2**
Salt Marsh	3.3	0.7	ns	**6.7**	**3.2**	**prefer**	**9.1**	**1.7**
Tidal Flat Barrens	0	0.3	ns	0.2	7.0	avoid	-	–
Salt-Killed Tundra	0	<0.1	ns	**9.3**	**5.1**	**prefer**	–	**12.7**
Deep Open Water without Islands	3.3	8.0	ns	4.3	3.4	ns	–	**0.6**
Deep Open Water with Islands or Polygonized Margins	**13.3**	**4.9**	**prefer**	**3.8**	**2.1**	**prefer**	–	**6.4**
Shallow Open Water without Islands	**11.7**	**1.2**	**prefer**	0.7	0.4	ns	–	–
Shallow Open Water with Islands or Polygonized Margins	**10.0**	**1.4**	**prefer**	**1.4**	**0.1**	**prefer**	**9.1**	**1.2**
River or Stream	1.7	0.9	ns	3.1	14.4	avoid	–	–
Sedge Marsh	1.7	2.2	ns	0.2	<0.1	ns	–	–
Deep Polygon Complex[d]	0	<0.1	ns	**27.6**	**2.7**	**prefer**	–	**24.9**
Grass Marsh	**5.0**	**0.4**	**prefer**	**1.0**	**0.2**	**prefer**	**9.1**	–
Young Basin Wetland Complex	0	0.3	ns	0	<0.1	ns	**9.1**	–
Old Basin Wetland Complex	**18.3**	**8.0**	**prefer**	0	<0.1	ns	**45.5**	–
Riverine Complex	0	0.4	ns	–	–	–	–	–
Dune Complex	1.7	0.9	ns	–	–	–	–	–
Nonpatterned Wet Meadow	3.3	3.9	ns	8.3	8.2	ns	**9.1**	**12.1**
Patterned Wet Meadow[d]	11.7	12.2	ns	20.7	19.3	ns	**9.1**	**35.3**
Moist Sedge-Shrub Meadow	1.7	19.2	avoid	0	2.3	avoid	–	–

Habitat	NE NPR-A Pre-breeding Use (%)[b]	NE NPR-A Pre-breeding Availability (%)	NE NPR-A Pre-breeding Preference[c]	Colville Pre-breeding Use (%)[b]	Colville Pre-breeding Availability (%)	Colville Pre-breeding Preference[c]	NE NPR-A Nesting[a] Use (%)	Colville Nesting[a] Use (%)
Moist Tussock Tundra	0	28.7	avoid	0.2	0.6	ns	–	–
Tall, Low, or Dwarf Shrub	0	4.7	ns	0	4.9	avoid	–	–
Barrens	0	1.1	ns	0.3	14.8	avoid	–	–
Human Modified	0	0	ns	0	0.1	ns	–	–
Total	**100**	**100**	**NA**	**100**	**100**	**NA**	**100**	**100**
Number of groups/nests	**60**	**NA**	**NA**	**579**	**NA**	**NA**	**11**	**173**

Note: NA (not applicable); NE (northeast); NPR-A (National Petroleum Reserve in Alaska); ns (not significant)

[a] Not all habitats were available in nest search areas; different areas were searched in different years; therefore, total availability of habitat is not presented.

[b] Use = (groups / total groups) × 100

[c] Significance calculated from 1,000 simulations at α = 0.05; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability for pre-breeding eider groups recorded on aerial surveys (Johnson, Parrett et al. 2018a, 2019).

[d] Habitats used by nesting spectacled eiders (*n* = 173 nests) on the Colville River Delta and in NE NPR-A (*n* = 11 nests) collected across multiple study sites (Johnson, Burgess et al. 2014).

1.2 Comparison of Alternatives: Birds

Effects to birds are detailed by habitat type and action alternative in Tables E.11.4 through E.11.14.

Table E.11.4 Acres of Bird Habitats Permanently Lost by Action Alternative

Habitat	Habitat Use (1 to 44 species)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Unmapped Area	NA	0.5	0.5	0.5
Dune Complex	1	0.8	0.8	0.8
Riverine Complex	3	1.0	1.2	0.8
Salt-Killed Tundra	3	–	–	–
River or Stream	4	0.6	0.4	0.6
Tapped Lake with Low-Water Connection	5	–	–	–
Tidal Flat Barrens	6	–	–	–
Human Modified	7[b]	0.1	0.1	0.1
Tapped Lake with High-Water Connection	9	–	–	–
Deep Open Water without Islands	11	–	0.3	–
Shallow Open Water without Islands	11	4.1	2.8	3.0
Barren	12	0.5	0.1	0.5
Deep Open Water with Islands or Polygonized Margins	14	–	–	–
Shallow Open Water with Islands or Polygonized Margins	14	2.4	1.2	2.8
Grass Marsh	15	–	0.5	–
Moist Tussock Tundra	18	397.4	417.5	390.3
Salt Marsh	21	–	–	–
Young Basin Wetland Complex	21	0.7	–	0.7
Open Nearshore Water	22	–	–	–
Deep Polygon Complex	25	–	–	–
Sedge Marsh	25	8.5	14.0	7.8
Tall, Low, or Dwarf Shrub	25	33.2	27.1	34.2
Old Basin Wetland Complex	27	26.3	34.1	19.9
Moist Sedge-Shrub Meadow	36	110.0	120.2	97.2
Nonpatterned Wet Meadow	39	20.4	27.1	18.7
Patterned Wet Meadow	44	65.7	69.2	62.2
Total high-use acres (>20 species)	**NA**	**264.8**	**291.7**	**240.7**
Total acres	**NA**	**672.2**	**717.1**	**640.1**

Note: NA (not applicable). All action alternatives include acres lost from the mine site. Numbers may differ slightly with other reported values in the environmental impact statement due to rounding. Acres of habitat lost is presented for bird habitats only; thus, the total gravel footprint may differ from total direct habitat loss, as some areas in the gravel footprint may not be bird habitat.

[a] As described in Section 3.11.1.2, *Bird Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for avian occurrence. Actual scores ranged from 1 (one species used the habitat) to 44 (44 species used the habitat). Shading denotes high-use habitats (at least 20 species use the habitat). See Table E.11.1 for more details on habitat values.

[b] Impoundments caused (in part) by dust shadows and early thaw on roadsides provide the earliest water available and attract considerable bird use (by spectacled eiders) before other areas are snow free (possible positive effect). Attraction to roadsides may also increase risk of collisions with vehicles (possible negative effect).

Table E.11.5. Acres of Bird Habitats Altered by Dust, Gravel Spray, Thermokarsting, or Impoundments by Alternative

Habitat	Habitat Use (1 to 44 species)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Unmapped Area	NA	11.0	11.0	11.0
Dune Complex	1	8.2	8.2	8.2
Riverine Complex	3	17.0	20.2	13.7
Salt-Killed Tundra	3	–	–	–
River or Stream	4	8.7	6.7	8.7
Tapped Lake with Low-Water Connection	5	–	–	–
Tidal Flat Barrens	6	–	–	–
Human Modified	7[b]	1.3	1.3	1.3
Tapped Lake with High-Water Connection	9	–	–	–
Deep Open Water without Islands	11	11.2	12.6	10.6
Shallow Open Water without Islands	11	36.4	33.2	24.8
Barren	12	10.9	6.6	10.9
Deep Open Water with Islands or Polygonized Margins	14	6.5	3.7	6.5
Shallow Open Water with Islands or Polygonized Margins	14	23.5	16.4	18.8
Grass Marsh	15	0.1	0.8	0.1
Moist Tussock Tundra	18	1,584.6	1,750.1	1,305.0
Salt Marsh	21	–	–	–
Young Basin Wetland Complex	21	6.9	1.8	6.9
Open Nearshore Water	22	–	–	–
Deep Polygon Complex	25	–	–	–
Sedge Marsh	25	68.2	72.8	35.0
Tall, Low, or Dwarf Shrub	25	270.4	209.4	264.1
Old Basin Wetland Complex	27	284.9	338.1	165.8
Moist Sedge-Shrub Meadow	36	406.4	390.3	283.3
Nonpatterned Wet Meadow	39	187.7	173.3	150.0
Patterned Wet Meadow	44	522.9	458.4	375.7
Total high-use acres (>20 species)	**NA**	1,747.4	1,644.1	1,280.8
Total acres	**NA**	3,466.8	3,514.9	2,700.4

Note: NA (not applicable)
[a] As described in Section 3.11.1.2, *Bird Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for avian occurrence. Actual scores ranged from 1 (one species used the habitat) to 44 (44 species used the habitat). Shading denotes high-use habitats (at least 20 species use the habitat). See Table E.11.1 for more details on habitat values.
[b] Impoundments caused (in part) by dust shadows and early thaw on roadsides provide the earliest water available and attract considerable bird use (by spectacled eiders) before other areas are snow free (possible positive effect). Attraction to roadsides may also increase risk of collisions with vehicles (possible negative effect).

Table E.11.6. Acres of Bird Disturbance and Displacement by Habitat Type within 656 feet (200 meters) of Gravel Infrastructure and Pipelines by Alternative

Habitat	Habitat Use (1 to 44 species)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Unmapped Area	NA	70.8	70.8	70.8
Dune Complex	1	11.7	11.7	12.5
Riverine Complex	3	48.7	63.7	45.6
Salt-Killed Tundra	3	–	–	–
River or Stream	4	39.4	39.5	39.4
Tapped Lake with Low-Water Connection	5	0.1	0.1	0.1
Human Modified	7[b]	2.5	2.5	2.5
Tapped Lake with High-Water Connection	9	1.8	1.8	1.8
Deep Open Water without Islands	11	107.8	109.0	107.0
Shallow Open Water without Islands	11	154.6	148.2	138.8
Barren	12	35.8	35.9	35.8
Deep Open Water with Islands or Polygonized Margins	14	120.0	110.1	120.0
Shallow Open Water with Islands or Polygonized Margins	14	92.8	82.7	85.1
Grass Marsh	15	26.6	27.3	26.5
Moist Tussock Tundra	18	3,890.9	4,307.4	3,676.2
Salt Marsh	21	0.6	0.6	0.6
Young Basin Wetland Complex	21	10.8	8.7	10.8
Deep Polygon Complex	25	27.0	27.0	27.0
Sedge Marsh	25	336.8	332.8	300.7
Tall, Low, or Dwarf Shrub	25	664.5	633.6	648.9
Old Basin Wetland Complex	27	773.2	855.5	621.1
Moist Sedge-Shrub Meadow	36	1,017.5	1,051.5	881.5
Nonpatterned Wet Meadow	39	637.9	624.4	605.1
Patterned Wet Meadow	44	1,604.0	1,569.9	1,495.8
Total high-use acres (by >20 species)	**NA**	**5,071.7**	**5,103.3**	**4,591.0**
Total acres	**NA**	**9,442.3**	**9,881.2**	**8,791.3**

Note: NA (not applicable). Disturbance zone estimated as 656 feet (200 meters) beyond the perimeter of gravel infrastructure and pipelines (summer terrestrial disturbance), where disturbance would alter behavior or displace birds, as indicated by the U.S. Fish and Wildlife Service disturbance and displacement buffer for spectacled eiders (USFWS 2015). Table does not include the gravel mine site since activity there would occur only in winter.

[a] As described in Section 3.11.1.2, *Bird Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for avian occurrence. Actual scores ranged from 1 (one species used the habitat) to 44 (44 species used the habitat). Shading denotes high-use habitats (at least 20 species use the habitat). See Table E.11.1 for more details on habitat values.

[b] Impoundments caused (in part) by dust shadows and early thaw on roadsides provide the earliest water available and attract considerable bird use (by spectacled eiders) before other areas are snow free (possible positive effect). Attraction to roadsides may also increase risk of collisions with vehicles (possible negative effect).

Table E.11.7. Comparison of Acres of Vegetation Damage from Ice Infrastructure and Volume of Water Withdrawn from Lakes by Alternative

Ice Infrastructure	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Ice infrastructure (vegetation damage and soil compaction) (acres)	2,872.3	3,400.3	4451.2	1,355.3	2,753.2
Multi-season ice pads (acres)[a]	30.0	30.0	25.8[b]	30.0	30.0
Freshwater use (millions of gallons)	1,874.0	2,047.2	2,433.8	521.2	1,004.9

[a] Acres are also included in total ice infrastructure on row 1.

[b] 30.0 acres of total multi-season ice pad but 4.2 acres would be covered by gravel footprint.

Table E.11.8. Estimated Project Traffic Rates for Action Alternatives

Traffic	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Ground traffic total trips	**3,009,933**	**2,340,368**	**3,187,363**
Vehicles per hour 2021 through 2027 (winter only)	68.0	62.9	60.5
Vehicles per hour 2021 through 2027 (winter and summer)	22.7	21.0	20.2
Vehicles per hour 2028 through 2032 (winter and summer)	11.9	9.6	22.2
Vehicles per hour 2033 through the life of the Project[a] (winter and summer)	7.4	4.2	6.6
Fixed-Wing total trips to Willow	**34,464**	**34,934**	**41,967**
Trips per day 2022 through 2027 (winter only)	9.3	9.7	10.0
Trips per day 2022 through 2027 (winter and summer)	3.1	3.2	3.3
Trips per day 2028 through 2032 (winter and summer)	3.6	3.7	6.7
Trips per day 2033 through the life of the Project[a] (winter and summer)	3.4	3.4	3.6
Fixed-Wing total trips to Alpine	**1,249**	**1,249**	**3,431**
Trips per day 2021 through 2027 (winter only)	1.2	1.2	1.3
Trips per day 2021 through 2027 (winter and summer)	0.4	0.4	0.4
Trips per day 2027 through 2032 (winter and summer)	0.1	0.1	0.6
Trips per day 2033 through the life of the Project[a] (winter and summer)	0.0	0.0	0.2
Helicopter total trips to Willow	**2,337**	**2,889**	**4,476**
Trips per day 2021 through 2027 (winter only)	0.5	1.1	0.6
Trips per day 2021 through 2027 (winter and summer)	0.2	0.4	0.2
Trips per day 2028 through 2032 (winter and summer)	0.2	0.2	0.6
Trips per day 2033 through the life of the Project[a] (winter and summer)	0.2	0.2	0.4
Helicopter total trips to Alpine	**141**	**126**	**182**
Trips per day 2020 through 2022 (winter only)	0.4	0.3	0.5
Trips per day 2020 through 2022 (winter and summer)	0.1	0.1	0.2

Note: Trips are one way. A single flight is a landing and subsequent takeoff; and a single vessel trip is a docking and subsequent departure.
[a] Life of the Project varies by alternative (Alternatives B and C: 2050; Alternative D: 2052)

Table E.11.9. Module Delivery Option Traffic Summary

Traffic	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Ground traffic total trips (winter)	2,306,087	2,846,987
Fixed-Wing trips to Willow (winter and summer)	150	230
Fixed-Wing trips to Alpine (winter and summer)	50	90
Fixed-Wing trips to Point Lonely (winter and summer)	–	90
Helicopter trips to Willow (winter and summer)	330	330
Helicopter trips to Alpine (winter and summer)	120	120

Note: Trips are one way. A single flight is a landing and subsequent takeoff; and a single vessel trip is a docking and subsequent departure.

Table E.11.10. Proponent's Module Transfer Island Traffic

Estimated Traffic	2021	2022	2023	2024	2025	2026
Ground vehicles per day (winter only)	358	1,153	359	8,874	359	7,800
Ground vehicles per hour (winter only)	15	48	15	370	15	325
Fixed-wing trips to Alpine (winter and summer)	25	25	0	0	0	0
Fixed-wing trips to Willow (winter and summer)	0	0	80	25	30	15
Helicopter trips to Alpine (winter and summer)	15	105	0	0	0	0
Helicopter trips to Willow (winter and summer)	0	105	65	55	60	45
Sealift barge trips (summer only)	0	0	5	0	1	0
Support vessel trips (summer only)	0	140	60	0	24	0

Note: Winter season is 122 days: December 15 through April 15. Summer (open water) season is 86 days: July 7 through September 30. Trips are one way. A single flight is a landing and subsequent takeoff; and a single vessel trip is a docking and subsequent departure.

Table E.11.11. Point Lonely Module Transfer Island Traffic

Estimated Traffic	2021	2022	2023	2024	2025	2026
Ground vehicles per day (winter only)	358	2,364	359	12,096	359	7,800
Ground vehicles per hour (winter only)	15	99	15	504	15	325
Fixed-Wing trips to Alpine (winter and summer)	25	65	0	0	0	0
Fixed-Wing trips to Willow (winter and summer)	0	0	100	45	50	35
Fixed-Wing trips to Point Lonely (summer only)	0	12	12	0	12	0
Fixed-Wing trips to Point Lonely (winter only)	0	24	0	18	0	18
Helicopter trips to Alpine (winter and summer)	15	105	0	0	0	0
Helicopter trips to Willow (winter and summer)	0	105	65	55	60	45
Total sealift barge trips (summer only[2])	0	0	5	0	1	0
Total support vessel trips (summer only[2])	0	140	60	0	24	0

Note: Winter season is 122 days: December 15 through April 15. Summer (open water) season is 86 days: July 7 through September 30. Trips are one way. A single flight is a landing and subsequent takeoff; and a single vessel trip is a docking and subsequent departure.

Table E.11.12. Estimated Numbers of Focal Bird Species per Square Mile in the 656-Foot (200-meter) Disturbance Zone around Project Infrastructure

Species	Alternative B: Proposed Action	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access Road	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Spectacled eider (mi^2)	0.1	0.1	0.1	–	–
Yellow-billed loon (mi^2)	0.2	0.2	0.1	–	–
Total	**0.3**	**0.3**	**0.2**	–	–

Source: USFWS 2016

Note: mi^2 (square miles). Calculation methods are described for spectacled eiders in Johnson, Shook et al. (2018). See Figures 3.11.4 and 3.11.5.

Table E.11.13. Estimated Numbers of Yellow-Billed Loon Breeding Sites near Project Facilities

Breeding Sites	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Nests (unique sites) within 1 mile of gravel infrastructure	8	7	8	ND	ND
Number of breeding lakes (with nests or broods) within 1,640 feet (500 m) of gravel infrastructure	4	4	3	ND	ND

Sources: Johnson, Parrett et al. (2019) and additional data on nests from BLM and USFWS registry.

Note: m (meters); ND (no data). Distances of 1 mile from a nest and 1,640 feet from a breeding lake are stipulated as no development areas in Best Management Practice E-11.

Table E.11.14. Acres of Spectacled Eider Preferred Habitat Affected by Action Alternative

Effect	Alternative B: Proposed Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Direct habitat loss	32.8	38.6	25.7	12.8	13.0
Indirect habitat alteration (dust shadow)	351.4	392.1	216.0	NA	NA
Disturbance zone[a]	1,194.7	1,251.3	1,019.0	72.5	72.7

Note: NA (not applicable). Preferred habitats are described in Table E.11.3.
[a] Disturbance zone estimated as 656 feet (200 meters) beyond the perimeter of gravel, where disturbance would alter behavior or displace birds, as indicated by the U.S. Fish and Wildlife Service disturbance and displacement buffer for spectacled eiders (USFWS 2015). Acres of disturbance is presented for bird habitats only; thus, the total disturbance may not be proportional to the total direct habitat loss, as some areas in the behavioral disturbance footprint may not be bird habitat.

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Willow Master Development Plan

Appendix E.12
Terrestrial Mammals Technical Appendix

August 2019

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List of Acronyms

ACP	Arctic Coastal Plain
BMP	best management practice
CAH	Central Artic Herd
CRD	Colville River Delta
km^2	square kilometers
LS	lease stipulations
m	meters
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
TCH	Teshekpuk Caribou Herd

Glossary Terms

Subnivean – Occurring beneath a layer of snow.

Ungulate – A hoofed mammal.

1.0 TERRESTRIAL MAMMALS

1.1 Species

At least 18 species of terrestrial mammals use the analysis area, and most remain in the analysis area year-round. Relative abundance and habitat use for mammals likely to be affected by the Willow Master Development Plan Project (Project) are summarized in Table E.12.1. Habitat use is depicted in Figure E.12.1. Habitat types and habitat use are described in more detail below in Section 1.2, *Habitats*.

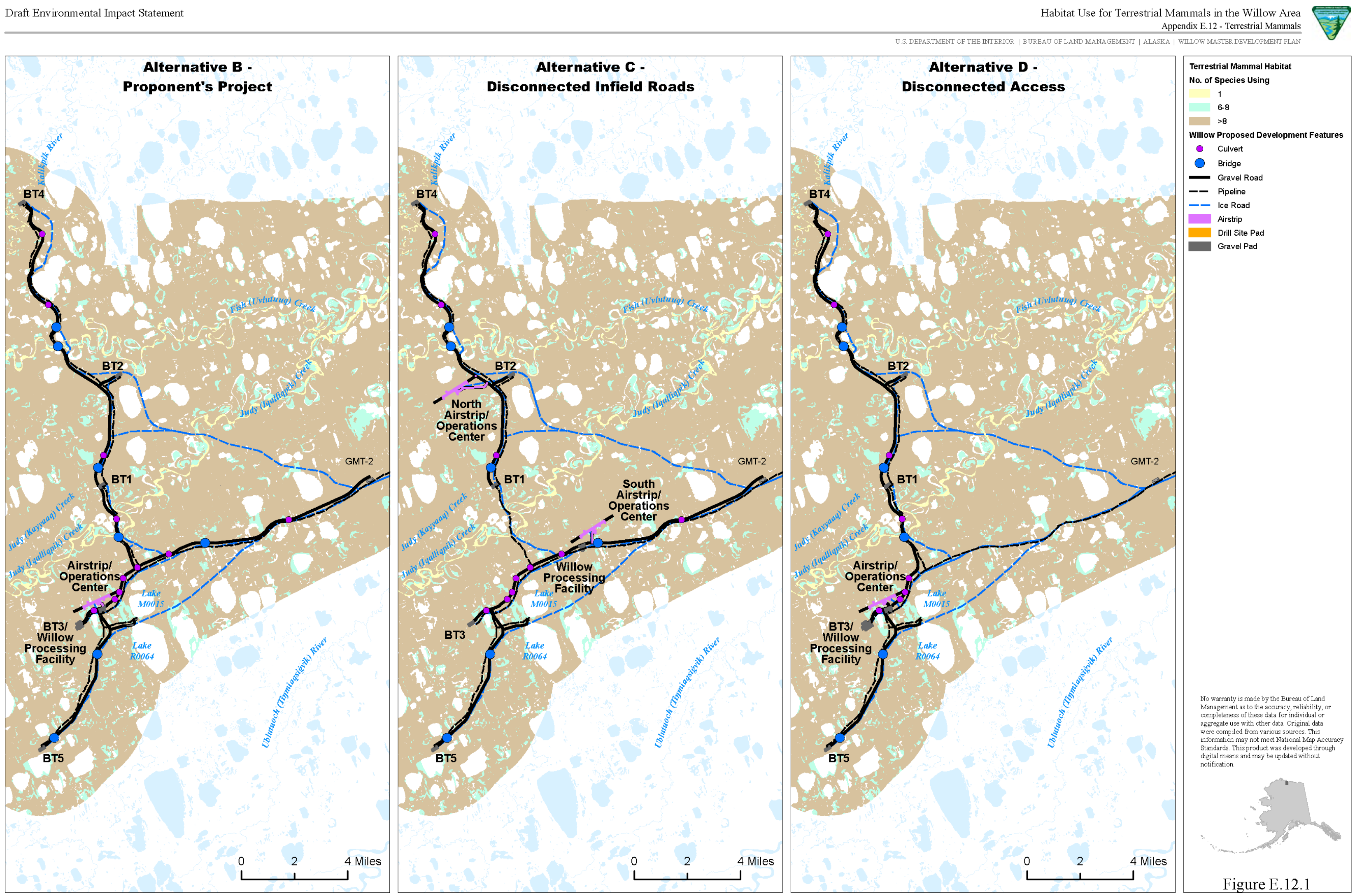

Figure E.12.1. Habitat Use for Terrestrial Mammals in the Willow Area

Table E.12.1. Terrestrial Mammal Species Likely to Use the Analysis Area

Common Name	Scientific Name	Habitat Use	Relative Abundance in Analysis Area	References
Arctic fox, red fox	*Vulpes lagopus, Vulpes vulpes*	Natal dens (summer): pingos, mounds, banks of streams and lakes; mainly in TLDS but also microsites in MSSM and PWM Foraging: broad use, depending on prey habitat use	Arctic fox: Common; moderate density, varying annually. Red fox: Low density; population increasing near oil fields	Arctic fox: Burgess 2000; Chesemore 1968; Eberhardt, Hanson et al. 1982; Red fox: Eberhardt 1977; Savory, Hunter et al. 2014; Stickney, Obritschkewitsch et al. 2014
Arctic ground squirrel	*Urocitellus parryii*	River terraces, banks, pingos, dunes, and mounds; mostly in TLDS but occasionally in other habitat types, depending on microsite suitability	Abundant; highest densities along river corridors	Barker and Derocher 2010; Batzli and Sobaski 1980; MacDonald and Cook 2009
Barren ground shrew	*Sorex ugyunak*	OBWC, YBWC, PWM, NPWM, MSSM, MTT, RICO, DUCO	Poorly known; probably low density	Bee and Hall 1956; MacDonald and Cook 2009
Brown lemming	*Lemmus trimucronatus*	Wetter habitats than collared lemming: PWM, NPWM, OBWC, YBWC, MTT, RICO	Less common than collared lemming; population fluctuates cyclically (often 3 to 4 years)	MacDonald and Cook 2009; Batzli and Lesieutre 1995; Garrott, Eberhardt et al. 1983
Caribou	*Rangifer tarandus*	Foraging: MSSM, MTT, TLDS, OBWC, YBWC, PWM, RICO Insect relief: BAR; HUMO; SKT; RICO; DUCO	Abundant	Kuropat 1984; Murphy and Lawhead 2000; Parrett 2007; Parrett 2015; Person, Prichard et al. 2007; Prichard, Welch et al. 2018; Wilson, Prichard et al. 2012
Collared lemming	*Dicrostonyx groenlandicus*	Drier habitats than brown lemming: TLDS, MSSM, DUCO	Common; population fluctuates cyclically (less frequently than brown lemming)	Batzli and Hentonnen 1990; Pitelka and Batzli 1993; Bee and Hall 1956; Batzli and Lesieutre 1995; MacDonald and Cook 2009
Ermine	*Mustela erminea*	OBWC, YBWC, PWM, NPWM, MSSM, MTT, TLDS, RICO	Uncommon; in habitats supporting lemmings and voles but fluctuating in abundance with those species	Bee and Hall 1956; MacDonald and Cook 2009
Grizzly (brown) bear	*Ursus arctos*	MSSM, TLDS, MTT, OBWC, YBWC, RICO, DUCO	Low density: 1.8 bears per 100 square miles in GMU 26B (lower density on coastal plain than in foothills and mountains)	Carroll 1995, 2013a; Lenart 2015a 2015c; Young and McCabe 1997; Shideler and Hechtel 2000
Least weasel	*Mustela nivalis*	OBWC, YBWC, PWM, NPWM, MSSM, MTT, TLDS	Uncommon; in habitats supporting lemmings and voles but fluctuating in abundance with those species	Bee and Hall 1956; MacDonald and Cook 2009

Common Name	Scientific Name	Habitat Use	Relative Abundance in Analysis Area	References
Moose	*Alces americanus*	TLDS, MSSM	Rare; generally restricted to riverine areas with tall shrubs; range expanding	Tape, Gustine et al. 2016; Carroll 2014; Mould 1977; Lawhead, Prichard, and Welch 2014; Lenart 2014
Muskox	*Ovibos moschatus*	TLDS, OBWC, PWM, MSSM, MTT, RICO	Rare, no groups currently using the area	Arthur and Del Vecchio 2009, 2013b; Danks and Klein 2002; Gustine, Barboza et al. 2011; Wilson and Klein 1991; Lenart 2015c
Root/tundra vole	*Microtus oeconomus*	Wetter habitats than singing vole: OBWC, YBWC, PWM, NPWM, MTT, RICO	Patchily distributed; populations fluctuate markedly between years	Batzli and Hentonnen 1990; Bee and Hall 1956; MacDonald and Cook 2009; Pruitt 1968
Singing vole	*Microtus miurus*	Drier habitats than root vole: TLDS, MSSM, DUCO	Uncommon; less common than farther inland (foothills)	MacDonald and Cook 2009; Batzli and Lesieutre 1995; Garrott, Eberhardt et al. 1983
Snowshoe hare	*Lepus americanus*	TLDS, especially along riverine corridors	Rare; restricted to areas of tall shrubs; population fluctuates cyclically	MacDonald and Cook 2009; Tape, Christie et al. 2016
Tundra shrew	*Sorex tundrensis*	Broad habitat use, especially drier terrestrial habitats	Poorly known; probably lower density than barren ground shrew	Bee and Hall 1956; MacDonald and Cook 2009
Wolf	*Canis lupus*	All terrestrial habitats, depending on prey habitat use	Rare; very low density: 1.8–2.9 wolves per 100 square miles in GMU 26A but lower on Arctic Coastal Plain	Caikoski 2012; Lawhead, Prichard, and Welch 2014; Harper 2012
Wolverine	*Gulo gulo*	All terrestrial habitats, depending on prey habitat use	Uncommon; low density	Carroll 2013b; Magoun 1979, 1985, 1987; Poley, Magoun et al. 2018; Delerum, Kunkel et al. 2009; Caikoski 2013

Source: Common and scientific names follow MacDonald and Cook's (2009) list, except that Bradley, Ammerman et al.'s (2014) list was used for taxonomic changes since 2009.

Note: BAR (Barren); DUCO (Dune Complex); GMU (Game Management Unit); HUMO (Human Modified); MSSM (Moist Sedge-Shrub Meadow); MTT (Moist Tussock Tundra); NPWM (Nonpatterned Wet Meadow); OBWC (Old Basin Wetland Complex); PWM (Patterned Wet Meadow); RICO (Riverine Complex); SKT (Salt-Killed Tundra); TLDS (Tall, Low, or Dwarf Shrub); YBWC (Young Basin Wetland Complex). Habitat use is depicted in Figure E.12.1.

1.1.1 Central Arctic Caribou Herd

The Central Arctic Herd (CAH) of caribou was estimated at approximately 5,000 animals when it was first described as a separate herd in the mid-1970s. The herd grew dramatically until the early 1990s, when it experienced a dip in numbers before increasing again to peak at an estimated 68,442 animals in July 2010. The herd then declined to an estimated 22,630 in July 2016, but has recovered modestly to 28,051 as of the July 2017 census (ADF&G 2017; Lenart 2015b, 2017, 2018). The decline was thought to be due to high adult mortality as well as emigration of some CAH to the Porcupine Herd or Teshekpuk Caribou Herd (TCH), which the CAH often intermixes with on their winter range (ADF&G 2017).

Most CAH caribou migrate onto the Arctic Coastal Plain (ACP) during May, shortly before the calving season (Nicholson, Arthur et al. 2016). The CAH calves from late May to mid-June in two general areas of the ACP: approximately half the herd calves between the Colville and Kuparuk rivers, with highest densities occurring south and southwest of the Kuparuk oil field; the other half of the herd calves east of the Prudhoe Bay oil field, between the Sagavanirktok and Canning rivers (Figure E.12.2) (Arthur and Del Vecchio 2009; Cameron, Smith et al. 2005; Lenart 2015b). Calving on the Colville River Delta (CRD) is rare (Lenart 2015b; Murphy and Lawhead 2000; Prichard, Macander et al. 2017) and few CAH females calve west of the Colville River (Lenart 2015b).

After calving, CAH caribou remain on the ACP during summer, repeatedly moving between inland foraging areas and coastal mosquito-relief habitat in response to weather-mediated fluctuations in insect activity levels (Figure E.12.2) (Lawhead 1988; Murphy and Lawhead 2000; White, Thomson et al. 1975). Over the last decade, portions of the herd have occasionally moved east nearly to the Canada border during July and then spread out across the eastern coastal plain in late summer, while others remained in the vicinity of the oil fields east of the Colville River (Arthur and Del Vecchio 2009; Lenart 2015b; Prichard, Macander et al. 2017). CAH caribou generally remain east of the CRD during the summer insect season, although movements onto and west of the CRD occur on rare occasions, judging from telemetry data and aerial survey observations. One such movement occurred in July 2001, when approximately 6,000 CAH caribou moved west across the CRD into the National Petroleum Reserve in Alaska (NPR-A) (Lawhead and Prichard 2002). The CAH typically winters in the southern foothills of the central Brooks Range, often mixing with Porcupine Herd animals there (Arthur and Del Vecchio 2009; Lenart 2015b; Nicholson, Arthur et al. 2016).

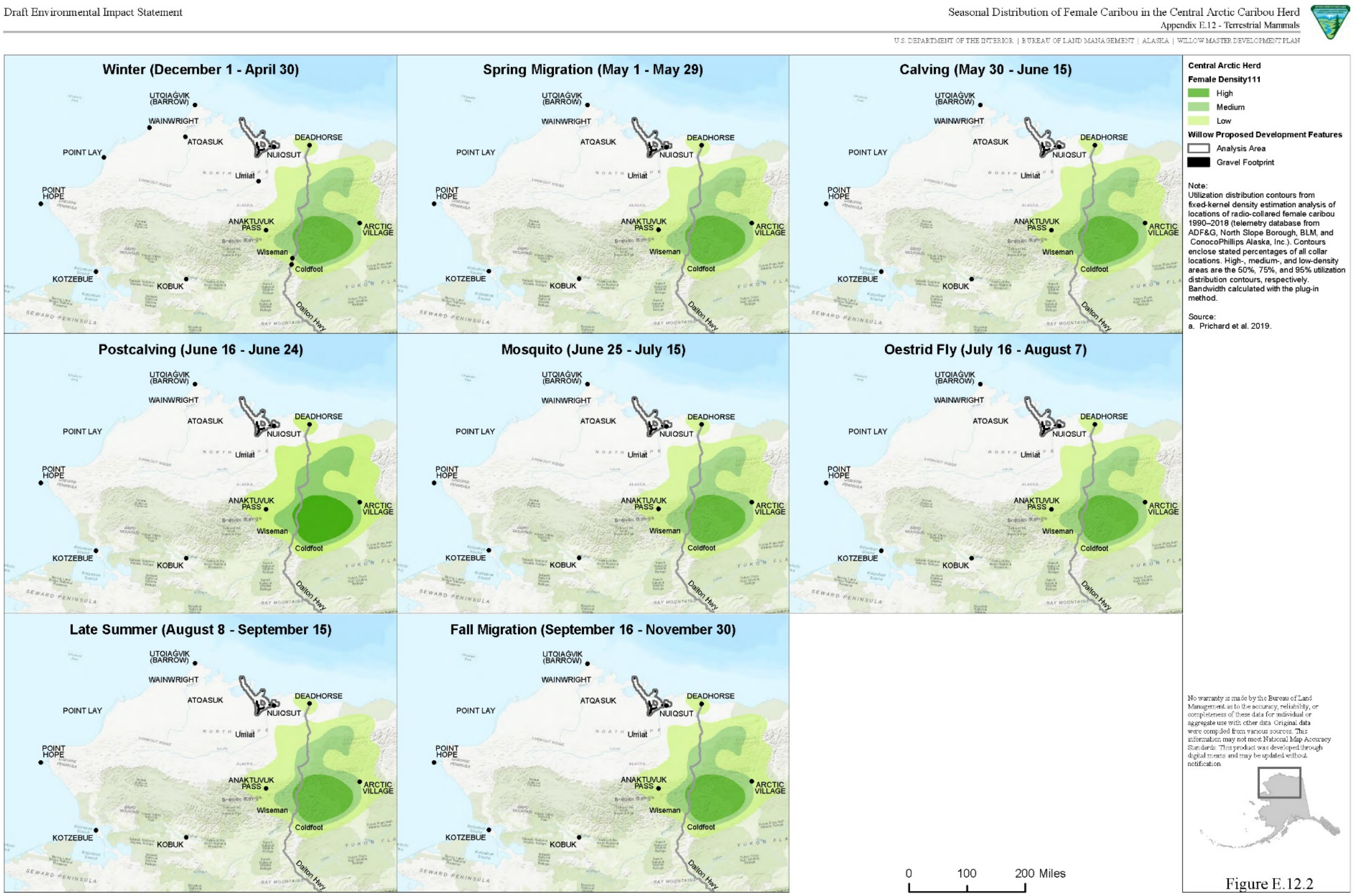

Figure E.12.2. Seasonal Distribution of Female Caribou in the Central Arctic Caribou Herd

1.1.2 Other Mammals

1.1.2.1 Foxes

Arctic foxes and red foxes occur in the analysis area year-round, although arctic foxes are more abundant (Johnson, Burgess et al. 2003). Both species use similar denning habitats, which include well-drained soils such as riverbanks, lake basins, and pingos. Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Johnson, Burgess et al. 2005; Stickney, Obritschkewitsch et al. 2014). In the Prudhoe Bay oil fields, red foxes have increased in abundance at a faster pace than arctic foxes, possibly due to warmer winters or higher tolerance of human presence (Stickney, Obritschkewitsch et al. 2014). Foxes in the oilfields are highly tolerant of humans and are often attracted to areas of human activities (Burgess 2000).

Arctic foxes range from the Brooks Range to the Beaufort Sea coast, but the highest abundance is on the ACP. Red foxes range throughout most of Alaska (MacDonald and Cook 2009). Arctic and red foxes prey on small mammals, such as lemmings, ground squirrels, and voles. Fluctuations in lemming abundance are often followed by fluctuations in the arctic fox population (Angerbjorn, Arvidson et al. 1991). Red foxes are omnivorous and opportunistic, eating a variety of items, including insects, small mammals, berries, and carrion. Both species will also scavenge eggs from ground-nesting birds (Hull 1994).

1.1.2.2 Grizzly Bears

Grizzly bears occur throughout the ACP in low densities (0.5–2.0 bears per 1,000 square kilometers [km^2]) compared to the mountains and foothills of the Brooks Range (10–30 bears per 1,000 km^2) (Carroll 1998). The lower density on the ACP is likely due to marginal habitat because of severe climate, a short growing season, and limited food resources. Grizzly bears of all ages and both sexes den during winter in pingos, river and lake banks, sand dunes, and steep gullies in uplands (Shideler and Hechtel 2000) that accumulate large snowdrifts for insulation. The Willow area contains some of these features and generally has more topography than areas further east on the central ACP. As a result, the area likely has suitable denning habitat for grizzly bears. Grizzly bears are opportunistic omnivores that rely on food sources that vary with the season. Small mammals, such as ground squirrels, are a common prey source in the NPR-A as are eggs of ground-nesting birds. In June, caribou calves are an important seasonal food source. Since 2001, incidental observations of grizzly bears and their dens have been recorded during aerial surveys for caribou and other wildlife throughout the analysis area (Johnson, Burgess et al. 2005; Lawhead, Prichard, and Welch 2014; Prichard, Welch et al. 2018). Moderate numbers of grizzly bears have used the North Slope oilfields in the last few decades (Shideler and Hechtel 2000), and can be attracted to areas of human activity, or garbage storage.

1.1.2.3 Moose

Moose occur in low densities on the ACP and their population has fluctuated substantially since 1992. Moose occur in a wide variety of habitat types during the summer, but generally prefer areas with tall shrub vegetation. In the analysis area, tall shrubs are generally associated with riverine drainages. During fall and winter, moose aggregate along riparian corridors of large river systems where they rely on tall willows for browse. The largest winter concentrations of moose on the western North Slope occur in the inland portions of the Colville River drainage (Carroll 2005). Moose have been recorded sporadically near Fish (Uvlutuuq and Iqalliqpik) Creek and Judy (Kayyaak and Iqalliqpik) Creek in the Willow area (Lawhead, Prichard et al. 2009; Lawhead, Prichard, Macander et al. 2014).

1.1.2.4 Muskoxen

Muskoxen historically occurred throughout northern Alaska, but over-harvesting led to their extirpation in the late 1800s or early 1900s (Hone 2013 [1934]; Smith 1989). Their population in northeastern Alaska was reestablished by translocation to Barter Island and the Kavik River in 1969 and 1970. As their numbers on the ACP increased, their range expanded westward to the Colville River and eastward to Babbage River in the Yukon (Lenart 2007; Reynolds 1998).

Although small numbers of muskoxen have occasionally been observed west of the Colville River, they are not considered common in the NPR-A (BLM 2012). Between 2001 and 2012, muskoxen herds as large as 25 individuals were occasionally recorded incidentally in the NPR-A near the Beaufort Sea coast along Harrison Bay. A group of six was recorded near Greater Mooses Tooth 2 in June 2001 (Lawhead and Prichard 2002). Nuiqsut residents report muskox using the Fish (Uvlutuuq and Iqalliqpik) Creek drainage (Jonah Nukapigak, Nuiqsut resident, personal communication to CPAI. June 6, 2018). Although their current population is reportedly stable or in slight decline (Arthur and Del Vecchio 2013a), the population on the central North Slope could potentially expand into the analysis area. Suitable habitat, which generally consists of riparian, upland shrub, and moist sedge shrub meadows, exists throughout the NPR-A (Danks 2000; Johnson, Burgess et al. 1996).

1.1.2.5 Wolves

Gray wolves occur throughout Alaska, occupy large home ranges, and travel maximum distances of 28 to 60 miles per day (Stephenson 1979). On the ACP, the highest wolf densities are near the Colville River and its tributaries, where winter moose densities are highest. Populations fluctuate substantially due to variability in prey availability and the severity of winters. Wolf abundance on the ACP is low relative to the foothills and mountains of the Brooks Range. This is thought to be due to the seasonal scarcity of caribou on the ACP, and poorer quality denning habitat than in the foothills and mountains. In addition to moose and caribou, wolves also prey on voles, lemmings, ground squirrels, and snowshoe hares (Hull 1994; Stephenson 1979). At last estimate, approximately 240 to 390 wolves in 32 to 53 packs were present on the western North Slope (Carroll 1998, 2006).

1.1.2.6 Wolverines

Wolverines are uncommon in the analysis area (BLM 2012; Johnson, Burgess et al. 2005; Lawhead, Prichard, and Welch 2014). On the North Slope, wolverines are closely associated with caribou, especially during calving and post-calving. They also rely heavily on caribou carcasses in the winter (BLM 1978; Magoun 1979). Two wolverines were seen incidentally during other surveys in the analysis area in 2013 (Lawhead, Prichard, and Welch 2014) as well as one each in 2001 and 2002 (ABR 2017, unpublished data). Wolverines occur across the ACP but are more common in the mountains and foothills of the Brooks Range (Bee and Hall 1956; BLM 1998; Poley, Magoun et al. 2018). In 1984, the Bureau of Land Management (2004) estimated a density of one wolverine per 140 km^2; however, Poley et al. (2018) found that the area southeast of Teshekpuk Lake had a higher probability of occupancy that most of the ACP in the NPR-A. Wolverines require large territories and use a broad range of habitats, frequently occurring in well-drained, drier areas such as tussock meadow, riparian willow, and alpine tundra habitats (BLM 1998; Poley, Magoun et al. 2018). Wolverines may avoid areas near human activity (May, Landa et al. 2006).

1.1.2.7 Small Mammals

Small mammals, including shrews, lemmings, voles, ground squirrels, and weasels, are important prey for predatory birds and carnivorous mammals on the ACP. Many small mammal species have cyclical population fluctuations that are often reflected, with a short temporal lag, in the population fluctuations of their predators. For example, snowy owl populations in northern Alaska are highly volatile and are closely associated with lemming abundance. Arctic ground squirrels hibernate during winter, whereas lemmings, voles, weasels, and shrews are active year-round, often underneath the snow.

1.2 Habitats

Habitats used by terrestrial mammals are summarized in Table E.12.2. The number of species that use each habitat type (as listed in Table E.12.1) are tallied in Tables E.12.2 and E.12.3.

Table E.12.2. Terrestrial Mammal Habitat Types

Habitat[a]	Description	Species Use[b]
Barren	Area without vegetation and not normally inundated.	1
Salt-Killed Tundra	Coastal low-lying areas where saltwater from storm surges has killed the original vegetation and colonization is occurring by salt-tolerant vegetation.	1
Human Modified	Area with vegetation or soil significantly disturbed by human activity.	3
Nonpatterned Wet Meadow	Analogous to sedge meadow or shrub meadow.	6
Dune Complex	Mosaic of swale and ridge features on inactive sand dunes, supporting wet to flooded sedge and moist shrub types in swales and moist to dry dwarf and low shrub types on ridges.	7
Riverine Complex	Mosaic of moist to wet sedge and shrub types, water, and barrens along flooded streams and associated floodplains.	8
Young Basin Wetland Complex	Complex ice-poor, drained-lake thaw basins characterized by a complex mosaic of vegetation classes and by surface water with a high percentage of Fresh Sedge Marsh and Fresh Grass Marsh.	9
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation dominated by tussock-forming plants, most commonly tussock cottongrass (*Eriophorum vaginatum*). Associated with high-centered polygons of low or high relief.	10
Old Basin Wetland Complex	Complex ice-rich habitat in older drained lake basins with well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice.	10
Patterned Wet Meadow	Lowland areas with low-centered polygons that are flooded in spring, with water remaining close to the surface throughout the growing season. Vegetation growth typically is more robust in polygon troughs than in centers. (See also Wet Sedge Meadow description in the Willow MDP EIS, Section 3.9, *Wetlands and Vegetation*.)	10
Tall, Low, or Dwarf Shrub	Woody plants that are smaller than trees and have several main stems arising at or near the ground.	12
Moist Sedge-Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and deposits formed by the movement of soil and other material. Soils saturated at intermediate depths (>0.5 feet) but generally free of surface water during summer.	13

Note: EIS (Environmental Impact Statement). Habitat use is depicted in Figure E.12.1. Shading depicts high habitat use (by nine or more species). Habitats described in other sections of the EIS are not used by terrestrial mammals and thus not included in the table.
[a] More information on these habitat types is in the Willow MDP EIS, Section 3.9, *Wetlands and Vegetation*.
[b] Indicates the number of species that typically use the habitat.

Table E.12.3. Habitat Use by Terrestrial Mammals

Habitat Type	Caribou	Muskox	Moose	Grizzly (brown) Bear	Foxes (2 species)	Arctic Ground Squirrel	Collared Lemming	Brown Lemming	Singing Vole	Snowshoe Hare	Root Vole	Weasels (2 species)	Shrews (2 species)	No. Species Using Habitat
Barren	IR	–	–	–	–	–	–	–	–	–	–	–	–	1
Salt-Killed Tundra	IR	–	–	–	–	–	–	–	–	–	–	–	–	1
Human Modified	IR	–	–	F, D	F, D	–	–	–	–	–	–	–	–	3
Nonpatterned Wet Meadow	–	–	–	–	–	–	–	U	–	–	U	U	U	6
Dune Complex	IR	–	–	F, D	D	U	U	–	U	–	–	–	U	7
Riverine Complex	F	F	–	F	F	–	–	U	–	–	U	U	U	8
Young Basin Wetland Complex	F	–	–	F	F	–	–	U	–	–	U	U	U	9
Patterned Wet Meadow	F	F	–	–	F, D	–	–	U	–	–	U	U	U	10
Moist Tussock Tundra	F	F	–	F	F	–	–	U	–	–	U	U	U	10
Old Basin Wetland Complex	F	F	–	F	–	U	–	U	–	–	U	U	U	10
Tall, Low, or Dwarf Shrub	F	F	F	F, D	F, D	U	U	–	U	U	–	U	–	12
Moist Sedge-Shrub Meadow	F	F	F	F, D	F, D	U	U	–	U	–	–	U	U	13

Note: – (not used); D (denning); F (foraging); IR (insect relief); No. (number); U (general use). Shading indicates high habitat use (nine or more species use the habitat).

1.3 Environmental Consequences to Species Other Than Caribou

1.3.1.1 Applicable Existing Lease Stipulations and Best Management Practices

All the existing lease stipulations (LS) and best management practices (BMPs) for caribou in Table 3.12.1 (in the Willow MDP Environmental Impact Statement [EIS], Section 3.12, *Terrestrial Mammals*) would also apply to other terrestrial mammals. Table E.12.4 summarizes other existing LS and BMPs that would apply to the Project and are intended to mitigate impacts to terrestrial mammals from development activity (BLM 2013). The LS and BMPs would reduce impacts to terrestrial mammal habitat, subsistence hunting areas, and the environment that are associated with the construction, drilling, and operation of oil and gas facilities.

Table E.12.4. Summary of Existing Lease Stipulations and Best Management Practices Intended to Mitigate Impacts to Terrestrial Mammals

LS or BMP	Description or Objective	Requirement
BMP A-1	Protect the health and safety of oil and gas field workers and the general public by disposing of solid waste and garbage in accordance with applicable federal, state, and local law and regulations.	Areas of operation shall be left clean of all debris.
BMP A-2	Minimize impacts on the environment from non-hazardous and hazardous waste generation. Encourage continuous environmental improvement. Protect the health and safety of oil field workers and the general public. Avoid human-caused changes in predator populations.	Prepare and implement a comprehensive waste management plan for all phases of exploration and development, including seismic activities.
BMP A-8	Minimize conflicts resulting from interaction between humans and bears during oil and gas activities.	Prepare and implement bear-interaction plans to minimize conflicts between bears and humans.
BMP C-1	Protect grizzly bear, polar bear, and marine mammal denning and/or birthing locations.	Cross-country use of heavy equipment and seismic activities is prohibited within one-half mile of occupied grizzly bear dens. Cross-country use of heavy equipment and seismic activity is prohibited within 1 mile of known or observed polar bear dens or seal birthing lairs.
BMP E-8	Minimize the impact of mineral materials mining activities on air, land, water, fish, and wildlife resources.	Gravel mine site design and reclamation will be in accordance with a plan approved by the authorized officer and in consultation with appropriate federal, state, and North Slope Borough regulatory and resource agencies.
BMP E-9	Avoidance of human-caused increases in populations of predators of ground-nesting birds.	Utilize best available technology to prevent facilities from providing nesting, denning, or shelter sites for ravens, raptors, and foxes. Feeding of wildlife is prohibited.
BMP M-4	Minimize loss of individuals of, and habitat for, mammalian species designated as Sensitive by the BLM in Alaska.	If development is proposed in an area that provides potential habitat for the Alaska tiny shrew, the proponent would conduct surveys at appropriate times of the year and in appropriate habitats in an effort to detect the presence of the shrew.

Source: BLM 2013.
Note: BMP (best management practice); LS (lease stipulation)

Similar types of effects as described for caribou under Alternative B (Proponent's Project) would also occur for other species. Effects unique to other species are described below.

1.3.2 <u>Habitat Loss or Alteration</u>

Alternative B would permanently remove 656.6 acres of terrestrial mammal habitat due to gravel fill or gravel mining. Tables E.12.5 and E.12.6 summarize habitat loss or alteration by habitat type. The largest amount of habitat loss would occur in moist tussock tundra, which is used by 10 species. If the mine site were connected to nearby streams during reclamation, the pit would be transformed into permanent open water habitat unsuitable for terrestrial mammals. Because the habitats lost are not unique and occur throughout the analysis area and ACP, caribou and other species would likely move to similar habitats nearby.

Use of gravel infrastructure would result in gravel spray and dust deposition, which would alter 3,312.1 acres of terrestrial mammal habitats within 328 feet (100 meters [m]) of gravel infrastructure (3,076.0 acres in high use habitats). Dust can change plant community composition or structure, and is discussed in detail in the Willow MDP EIS, Section 3.9, *Wetlands and Vegetation*.

Arctic ground squirrels and other small mammals would lose foraging and burrow habitat and grizzly bears could lose minor amounts of foraging. Impacts would be at an individual level and likely would not affect the population.

Compressed snow and ice from ice infrastructure and from snow-removal on gravel roads would temporarily alter habitats by delaying snow melt and compacting vegetation. Ermine, short-tailed weasel, least weasel, collared lemming, brown lemming, singing vole, root and tundra mole, barren ground shrew, and tundra shrew remain active all winter and thus their winter habitats are vulnerable to crushing from placement of ice, snow, and gravel for road and pad construction. These mammals may relocate to avoid impacts of winter construction. Arctic ground squirrels hibernate in winter and are unable to relocate in response to winter construction activities.

1.3.3 Disturbance or Displacement

Disturbance of grizzly bears during winter denning has the potential to displace bears from their dens, imposing large energetic costs on adults and risking mortality of cubs (Amstrup 1993; Clough, Patton et al. 1987; Linnell, Swenson et al. 2000; Reynolds 1986) . Snow cover greatly attenuates sounds, and Project activities would not likely disturb bears in dens at distances greater than 328 feet (100 m) (Blix and Lentfer 1992), although activities may be detectable above background levels at 0.3 to 1.25 miles (0.5 to 2 kilometers), depending on the stimulus (LGL Limited Environmental Research Associates and JASCO Research Ltd. 2003). The most audible disturbance stimuli inside bear dens would be an underground blast (gravel mining) or airborne helicopters directly overhead. Studies have noted high variability in the tolerance of bears to noise and disturbance (LGL Limited Environmental Research Associates and JASCO Research Ltd. 2003).

Existing best management practice (BMP) C-1 for the NPR-A stipulate that occupied grizzly bear dens must be avoided by a distance of 0.5 mile. Grizzly bears may abandon dens because of disturbance (Clough, Patton et al. 1987; Swenson, Sandegren et al. 1997). Although the analysis area likely provides suitable denning habitat, the number of bears denning near Project facilities in a single year would be low, thus reducing the risk of disturbance; however, females denning with cubs would be of most concern. Because bank habitats along Fish (Uvlutuuq and Iqalliqpik) Creek and Judy (Kayyaak and Iqalliqpik) Creek are suitable for bear dens in the analysis area, den surveys would be conducted prior to construction. Ongoing consultation with agency biologists monitoring radio-collared bears in the region would provide exact location information to avoid the dens of marked individuals, although uncollared bears also occur in the area.

Wolverines could be displaced from areas of increased human activity and could experience higher risk of human-caused mortality (May, Landa et al. 2006).

1.3.4 Injury or Mortality

Foxes are present and active year-round in the analysis area and would be subject to vehicle strikes during all seasons. In general, however, the scheduling of the heaviest construction-related traffic during the winter would help to reduce the potential for vehicles to strike terrestrial mammals.

Small terrestrial mammals with limited mobility and small home ranges could be directly killed within the footprints of ice road construction, gravel excavation, and gravel placement. In addition, individual lemmings, voles, and shrews may experience indirect mortality due to habitat disruption and fragmentation from the compaction of **subnivean** spaces by ice road construction and from construction of gravel roads and pads, which would pose barriers to small-mammal movement.

1.3.5 Attraction to Human Activities and Facilities

Foxes and grizzly bears are attracted to areas of human activity, where they feed on garbage and handouts (Eberhardt, Hanson et al. 1982; Follmann 1989; Follmann and Hechtel 1990; LGL Ecological Research Associates 1993; Shideler and Hechtel 2000). Their presence near human activity increases the potential for animals to be struck by vehicles, ingest toxic substances, or be killed by humans in defense of life or property. Foxes and, to a lesser extent, grizzly bears, may use human structures, such as gravel embankments and empty pipes, for denning (Burgess, Rose et al. 1993; Shideler and Hechtel 2000).

Increased predator populations around oil field developments may increase predation on prey populations (Day 1998; Martin 1997). This impact is inferred from the higher number of foxes, increased density of fox dens (Burgess 2000; Burgess, Rose et al. 1993; Eberhardt, Hanson et al. 1982), and higher numbers of bears (Shideler and Hechtel 2000) in the North Slope oil fields. Foxes prey on birds and small terrestrial mammals, and bears prey on caribou, muskoxen, ground squirrels, and bird nests. Red fox may displace arctic fox and kill pups. Increases in mortality of **ungulate** calves by fox or bear may affect populations locally, although there is little information to suggest population-level effects occur with any regularity. Grizzly bear predation of muskoxen is difficult to quantify. It is unlikely that bear predation depresses the caribou population substantially, although the muskox population appears to be more affected.

Human-animal interactions would occur during all seasons and all phases of the Project but would be likely to occur most frequently during construction when human activity would be most intensive and widespread. Lower levels of human activity during drilling and operations would result in correspondingly lower rates of human-animal interactions.

Control of food waste and other garbage would help minimize predators and scavengers being attracted to facilities. Existing BMPs and company policies against feeding animals would be strictly enforced. Proper containment and removal of garbage and hazardous waste at camps and drill sites would minimize the attraction of predators and the risks to animals. A Wildlife Avoidance and Interaction Plan and environmental awareness program for all Project employees would be required to address waste-handling practices and bear interactions. Even with effective enforcement of these policies, attraction of predators and scavengers would be likely.

1.4 Alternatives Comparison Tables: All Species

Habitat loss and alteration is summarized by land-based alternative in Tables E.12.5 and E.12.6. Table E.12.7 summarizes Project components that would contribute to effects caribou. Table E.12.8 summarizes the proportion of the TCH seasonal range within 2.5 miles of new gravel infrastructure by action alternative and module delivery option.

Table E.12.5 Acres of Terrestrial Mammal Habitats Permanently Lost by Action Alternative

Habitat	Habitat Value (1 to 13)[a]	Acres in the Analysis Area	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Unmapped Area	NA	447,366.4	0.5	0.5	0.5
Barren	1	8,157.0	0.5	0.1	0.5
Salt-Killed Tundra	1	89.7	–	–	–
Human Modified	3[b]	427.1	0.1	0.1	0.1
Nonpatterned Wet Meadow	6	14,877.6	20.4	27.1	18.7
Dune Complex	7	1,763.0	0.8	0.8	0.8
Riverine Complex	8	961.2	1.0	1.2	0.8
Young Basin Wetland Complex	9	661.7	0.7	–	0.7
Moist Tussock Tundra	10	79,468.7	397.4	417.5	390.3
Old Basin Wetland Complex	10	17,686.3	26.3	34.1	19.9
Patterned Wet Meadow	10	46,442.5	65.7	69.2	62.2
Tall, Low, or Dwarf Shrub	11	21,029.4	33.2	27.1	34.2
Moist Sedge-Shrub Meadow	13	47,925.0	110.0	120.2	97.2
Total high-use habitat acres	**NA**	**213,213.6**	**633.3**	**668.3**	**604.5**
Total acres	**NA**	**753,351.1**	**656.6**	**698.1**	**625.9**

Note: NA (not applicable). All action alternatives include acres lost from the mine site.
[a] As described above in Section 1.2, *Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for species occurrence. Shading denotes high-use habitats (use by nine or more species). See Tables E.12.2 and E.12.3 for more details on habitat use.
[b] Seasonal use of areas with fewer insects (possible positive effect). Attraction to roads may also increase risk of collisions with vehicles (possible negative effect).

Table E.12.6. Acres of Terrestrial Mammal Habitats Altered by Dust, Gravel Spray, Thermokarsting, or Impoundments by Action Alternative

Habitat	Habitat Value (1 to 13)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access
Unmapped Area	NA	11.0	11.0	11.0
Barren	1	10.9	6.6	10.9
Salt-Killed Tundra	1	–	–	–
Human Modified	3[b]	1.3	1.3	1.3
Nonpatterned Wet Meadow	6	187.7	173.3	150.0
Dune Complex	7	8.2	8.2	8.2
Riverine Complex	8	17.0	20.2	13.7
Young Basin Wetland Complex	9	6.9	1.8	6.9
Moist Tussock Tundra	10	1,584.6	1,750.1	1,305.0
Old Basin Wetland Complex	10	284.9	338.1	165.8
Patterned Wet Meadow	10	522.9	458.4	375.7
Tall, Low, or Dwarf Shrub	11	270.4	209.4	264.1
Moist Sedge-Shrub Meadow	13	406.4	390.3	283.3
Total high-use habitat acres	**NA**	**3,076.1**	**3,148.1**	**2,400.8**
Total acres	**NA**	**3,312.2**	**3,368.7**	**2,595.9**

Note: NA (not applicable). Table depicts area potentially altered by dust generated from vehicles or wind on gravel fill (328-foot [100-meter] radius from gravel infrastructure).
[a] As described in F.12.2, *Habitats*, habitats were ranked by the number of species using them to portray areas with the highest potential for species occurrence. Shading denotes high-use habitats (use by nine or more species). See Tables E.12.2 and E.12.3 for more details on habitat use.
[b] Seasonal use of areas with fewer insects (possible positive effect). Attraction to roadsides may also increase risk of collisions with vehicles (possible negative effect).

Table E.12.7. Project Components that Contribute to Effects to Caribou

Component	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island
Habitat loss[a] (acres, gravel fill and gravel mining)	656.6	698.1	625.9	0	0
Habitat alteration (dust shadow) (acres)	3,312.1	3,368.7	2,595.8	0	0
Habitat alteration (vegetation compaction from ice infrastructure) (acres)	923.6	906.8	921.3	752.9	1,259.0
Habitat alteration (multi-season ice pads) (acres, also included in total ice infrastructure)	30.0	30.0	25.8	30.0	30.0
Disturbance (within 2.5 miles of new gravel infrastructure) (acres)	121,469.1	125,643.8	107,406.3	NA	NA
Acres of new gravel infrastructure[a]	442.7	487.8	410.7	NA[b]	NA[b]
Miles of pipeline rack on new VSMs[a]	93.2	94.3	92.2	0	0
Miles of gravel road	38.2	36.8	28.3	0	0
Miles of onshore ice road	372.0	471.0	694.5	109.9	227.9
Ground traffic[c] (Project total)	3,009,933	2,340,368	3,187,363	2,306,087	2,846,987
Fixed-Wing air traffic[d] (Project total)	35,713	36,183	45,398	200	320
Helicopters traffic (Project total)	2,478	3,025	4,658	450	450
Closest proximity of summer construction to high-density caribou calving (miles)	1.1	1.1	1.1	NA[f]	NA[f]
Closest proximity of summer construction to high-density caribou post-calving (miles)	4	4	4	12.3	2.4
Closest proximity of summer construction to high-density caribou mosquito relief (miles)	6.7	6.7	6.7	9.6	0.5
Closest proximity of summer construction to high-density caribou oestrid fly relief (miles)	0	0	0	1.3	0

Note: NA (not applicable)
[a] Gravel or areas under pipeline infrastructure would also be used by caribou during insect relief.
[b] Acres would not be accessible to terrestrial mammals.
[c] Includes buses, light commercial trucks, short-haul trucks, passenger trucks, and other miscellaneous vehicles. Ground transportation also includes gravel hauling operations (i.e., B70 or maxi dump trucks).
[d] Flights outlined are additional flights required beyond projected travel to/from non-Project airports (e.g., Anchorage, Fairbanks, Deadhorse). Fixed-wing aircraft includes C-130, DC-6, Twin Otter or CASA, Cessna, or similar.
[e] Includes support for ice road construction, pre-staged boom deployment, hydrology and other environmental studies, and agency inspection during all phases of the Project.
[f] Summer construction at either module transfer site would not occur during calving.

Table E.12.8. Percent of the Teshekpuk Caribou Herd Seasonal Range within 2.5 Miles of New Gravel Infrastructure by Action Alternative and Module Delivery Option

Percentage of Seasonal Range	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island[a]	Analysis Area
Spring migration	1.12	1.17	1.01	0.01	0.01	6.50
Calving	0.89	0.93	0.81	0.02	0.07	12.12
Calving (maternal females only)	0.76	0.78	0.70	0.02	0.07	14.80
Post-calving	0.72	0.74	0.65	0.02	0.24	14.28
Mosquito season	0.32	0.33	0.31	0.04	0.79	19.38
Oestrid fly season	0.71	0.74	0.65	0.04	0.27	11.91
Late summer	1.46	1.52	1.33	0.03	0.02	8.22
Fall migration	1.57	1.64	1.41	0.02	0.01	7.43
Winter	0.91	0.95	0.80	0.01	0.01	4.46

Source: ABR Inc. 2019

Note: Percentages based on the proportion of use distribution calculated using kernel density estimation for each season.

[a] Percent of caribou herd within 2.5 miles (4 kilometers) of new and existing gravel infrastructure at Point Lonely.

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